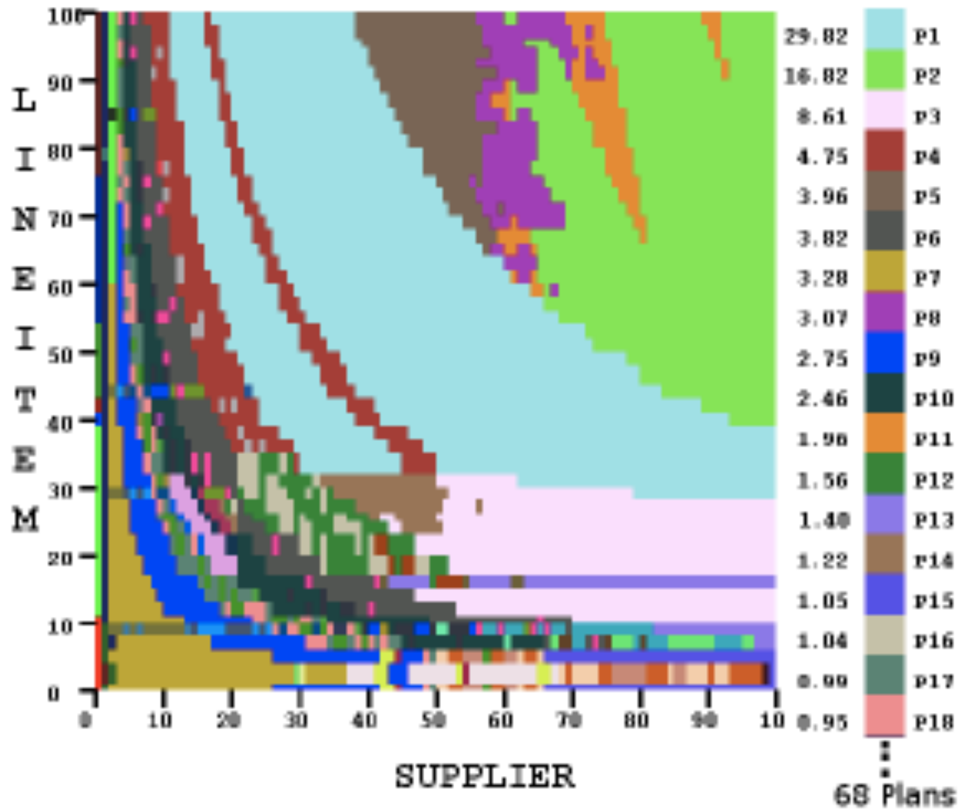
CSE 544
Parallel Databases

Tuesday, February 17th, 2011

Final Thoughts on Optimization: Parameters !



Chaudhuri "Rethinking the Contract"

Overview of Today's Lecture

- Parallel databases (Chapter 22.1 – 22.5)
- Map/reduce
- Pig-Latin
  - Some slides from Alan Gates (Yahoo! Research)

Parallel v.s. Distributed Databases

- Parallel database system:
  - Improve performance through parallel implementation
  - Will discuss in class
- Distributed database system:
  - Data is stored across several sites, each site managed by a DBMS capable of running independently
  - Will not discuss in class

Parallel DBMSs

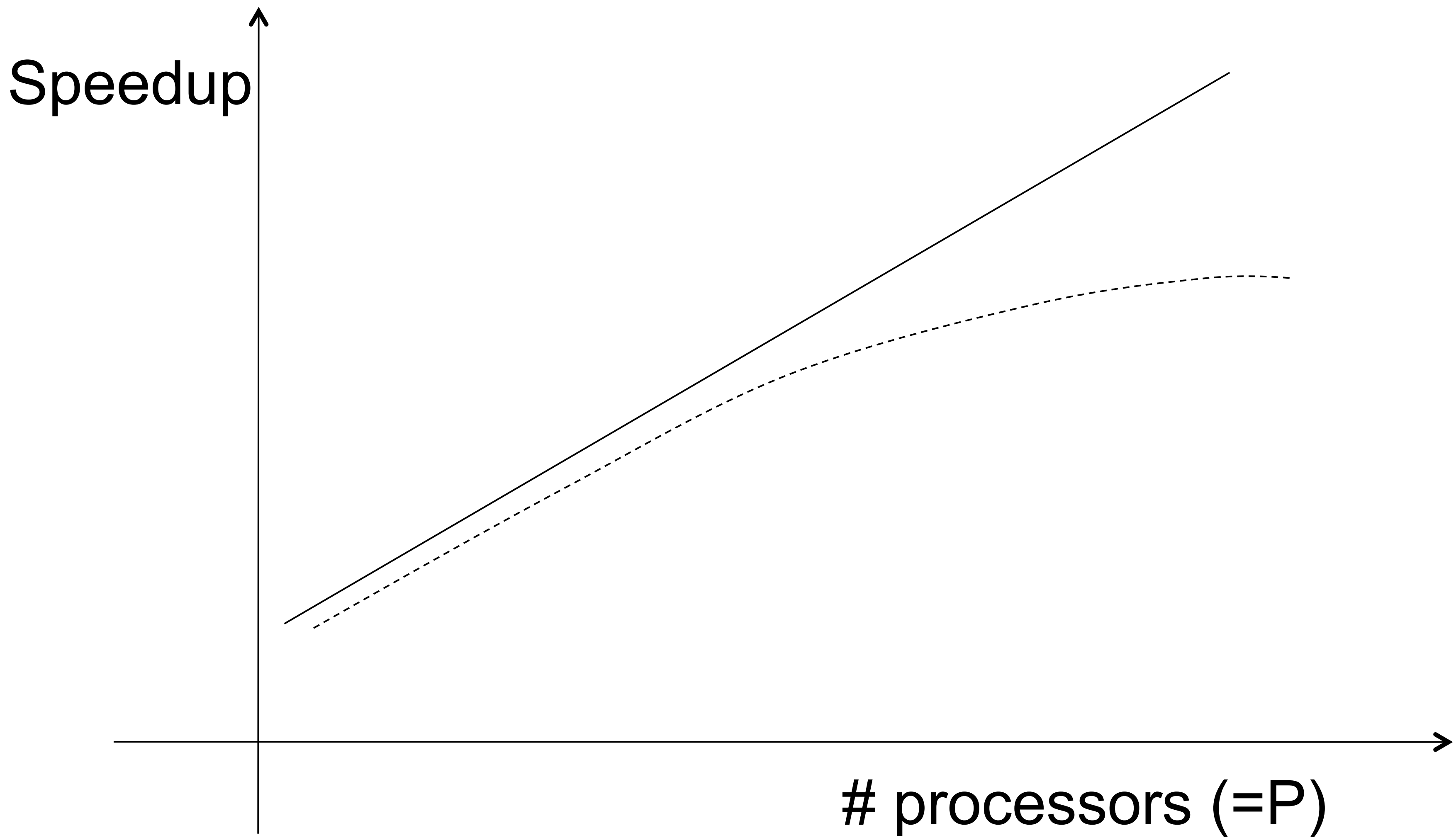
- Goal
  - Improve performance by executing multiple operations in parallel
- Key benefit
  - Cheaper to scale than relying on a single increasingly more powerful processor
- Key challenge
  - Ensure overhead and contention do not kill performance

Performance Metrics for Parallel DBMSs

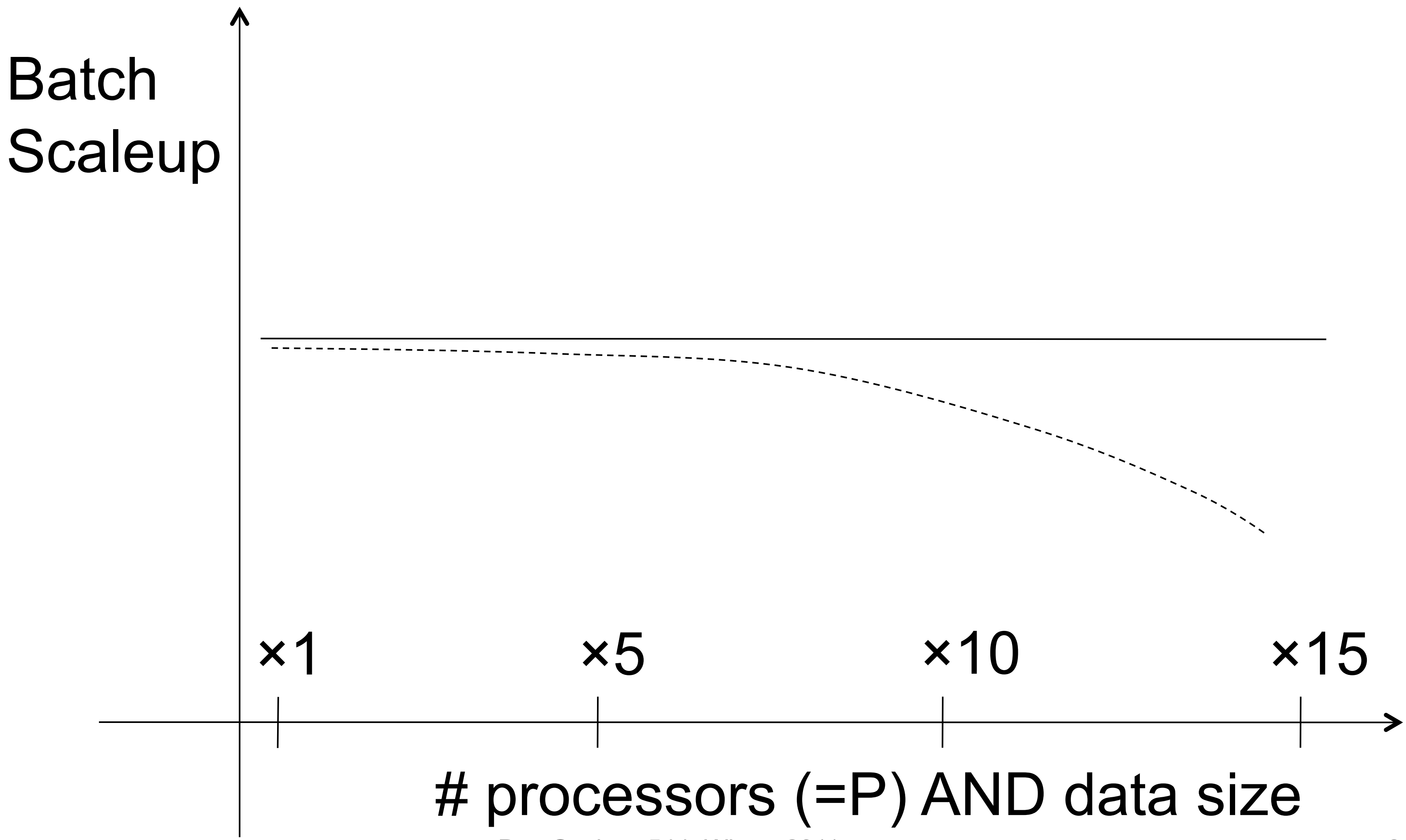
- Speedup
  - More processors ➔ higher speed
  - Individual queries should run faster
  - Should do more transactions per second (TPS)

- Scaleup
  - More processors ➔ can process more data
  - Batch scaleup
    - Same query on larger input data should take the same time
  - Transaction scaleup
    - N-times as many TPS on N-times larger database
    - But each transaction typically remains small

Linear v.s. Non-linear Speedup



Linear v.s. Non-linear Scaleup



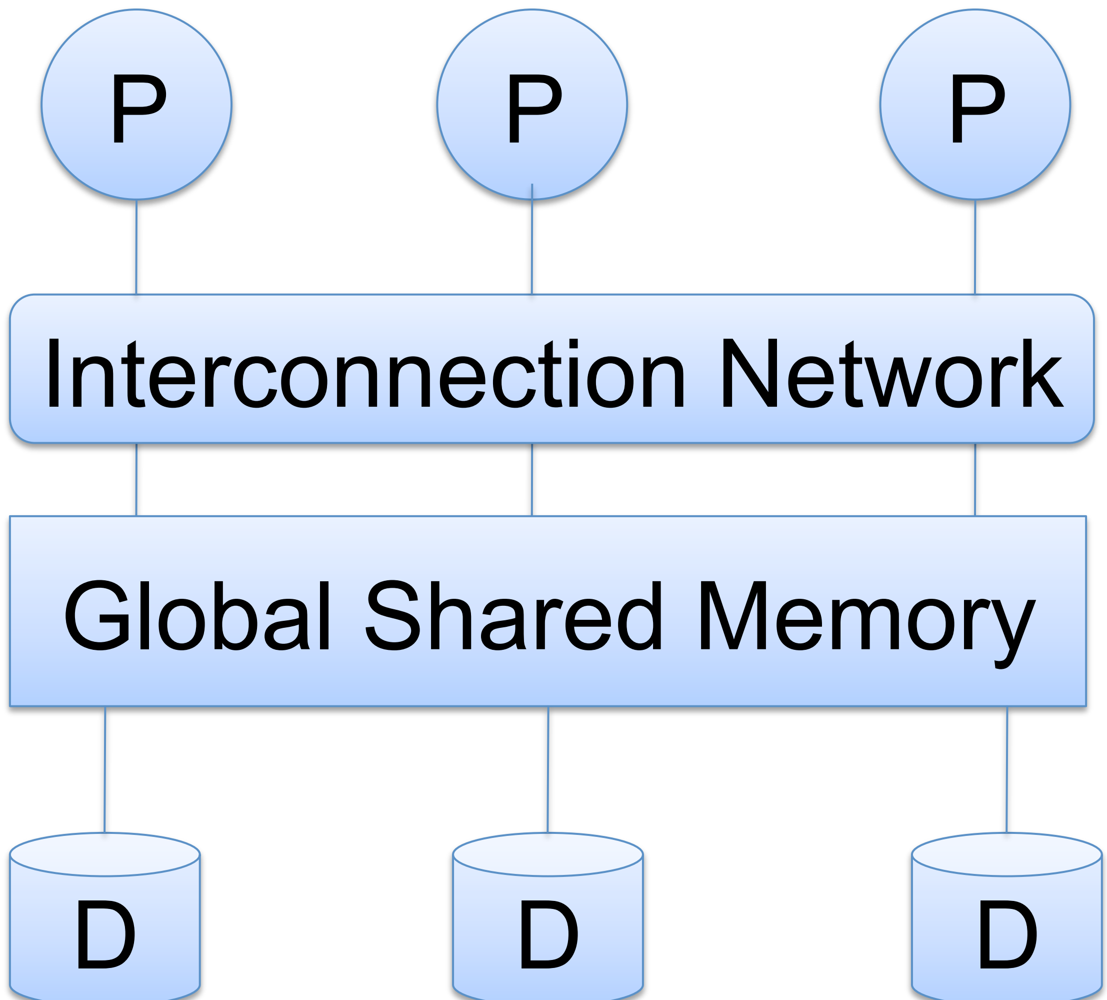
Challenges to Linear Speedup and Scaleup

- Startup cost
  - Cost of starting an operation on many processors
- Interference
  - Contention for resources between processors
- Skew
  - Slowest processor becomes the bottleneck

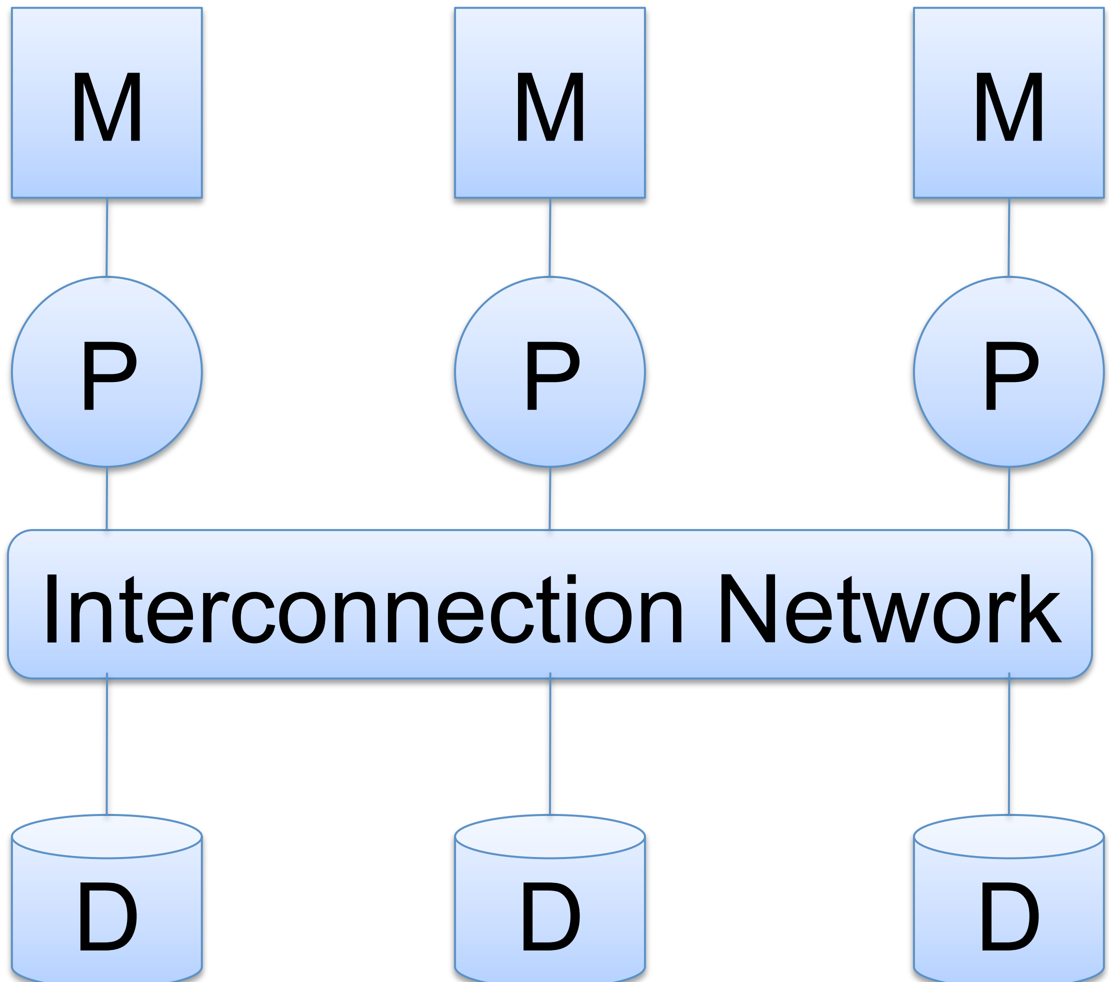
Architectures for Parallel Databases

- Shared memory
- Shared disk
- Shared nothing

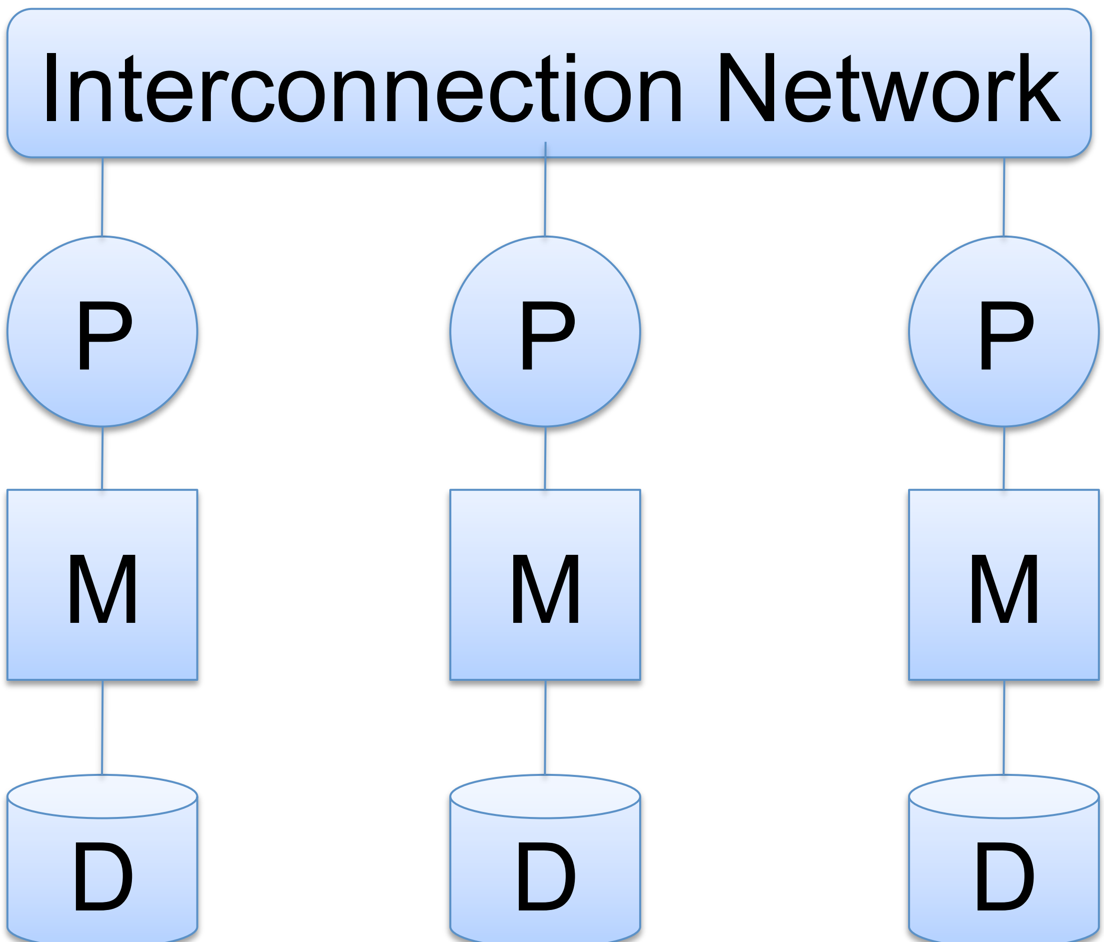
Shared Memory



Shared Disk



Shared Nothing



Shared Nothing

- Most scalable architecture
  - Minimizes interference by minimizing resource sharing
  - Can use commodity hardware

- Also most difficult to program and manage

- Processor = server = node
- P = number of nodes

We will focus on shared nothing

Taxonomy for Parallel Query Evaluation

- Inter-query parallelism
  - Each query runs on one processor
- Inter-operator parallelism
  - A query runs on multiple processors
  - An operator runs on one processor
- Intra-operator parallelism
  - An operator runs on multiple processors

We study only intra-operator parallelism: most scalable

Horizontal Data Partitioning

- Relation R split into P chunks $R_0, \ldots, R_{P-1}$, stored at the P nodes

- Round robin: tuple t_i to chunk (i mod P)

- Hash based partitioning on attribute A:
  – Tuple t to chunk h(t.A) mod P

- Range based partitioning on attribute A:
  – Tuple t to chunk i if $v_{i-1} < t.A < v_i$

Parallel Selection

Compute $\sigma_{A=v}(R)$, or $\sigma_{v1<A<v2}(R)$

- Conventional database:
  - Cost = B(R)

- Parallel database with P processors:
  - Cost = B(R) / P

Parallel Selection

Different processors do the work:

- Round robin partition: all servers do the work
- Hash partition:
  - One server for $\sigma_{A=v}(R)$,
  - All servers for $\sigma_{v1<A<v2}(R)$
- Range partition: one server does the work

Data Partitioning Revisited

What are the pros and cons ?

- Round robin
  - Good load balance but always needs to read all the data
- Hash based partitioning
  - Good load balance but works only for equality predicates and full scans
- Range based partitioning
  - Works well for range predicates but can suffer from data skew

Parallel Group By: $\gamma_{A,\ sum(B)}(R)$

Step 1: server i partitions chunk R_i using a hash function h(t.A): R_{i0}, R_{i1}, …, $R_{i,P-1}$

Step 2: server i sends partition R_{ij} to server j

Step 3: server j computes $\gamma_{A,\ sum(B)}$ on R_{0j}, R_{1j}, …, $R_{P-1,j}$

Cost of Parallel Group By

Recall conventional cost = 3B(R)

- Step 1: Cost = B(R)/P I/O operations
- Step 2: Cost = (P-1)/P B(R) blocks are sent
  - Network costs << I/O costs
- Step 3: Cost = 2 B(R)/P
  - When can we reduce it to 0 ?

Total = 3B(R) / P + communication costs

Parallel Join: $R \bowtie_{A=B} S$

Step 1

- For all servers in [0,k], server i partitions chunk R_i using a hash function h(t.A): R_{i0}, R_{i1}, …, $R_{i,P-1}$
- For all servers in [k+1,P], server j partitions chunk S_j using a hash function h(t.A): S_{j0}, S_{j1}, …, $R_{j,P-1}$

Step 2:

- Server i sends partition R_{iu} to server u
- Server j sends partition S_{ju} to server u

Steps 3: Server u computes the join of R_{iu} with S_{ju}

Cost of Parallel Join

- Step 1: Cost = (B(R) + B(S))/P

- Step 2: 0
  - (P-1)/P (B(R) + B(S)) blocks are sent, but we assume network costs to be << disk I/O costs

- Step 3:
  - Cost = 0 if small table fits in memory: B(S)/P <=M
  - Cost = 4(B(R)+B(S))/P otherwise

Parallel Query Plans

- Same relational operators
- Add special split and merge operators
  - Handle data routing, buffering, and flow control
- Example: exchange operator
  - Inserted between consecutive operators in the query plan

Map Reduce

- Google: paper published 2004
- Free variant: Hadoop

- Map-reduce = high-level programming model and implementation for large-scale parallel data processing

Data Model

Files !

A file = a bag of `(key, value)` pairs

A map-reduce program:

- Input: a bag of `(inputkey, value)` pairs
- Output: a bag of `(outputkey, value)` pairs

Step 1: the MAP Phase

User provides the MAP-function:

- Input: one `(input key, value)`
- Ouput: bag of `(intermediate key, value)` pairs

System applies the map function in parallel to all `(input key, value)` pairs in the input file

Step 2: the REDUCE Phase

User provides the REDUCE function:

- Input: `(intermediate key, bag of values)`
- Output: bag of output `values`

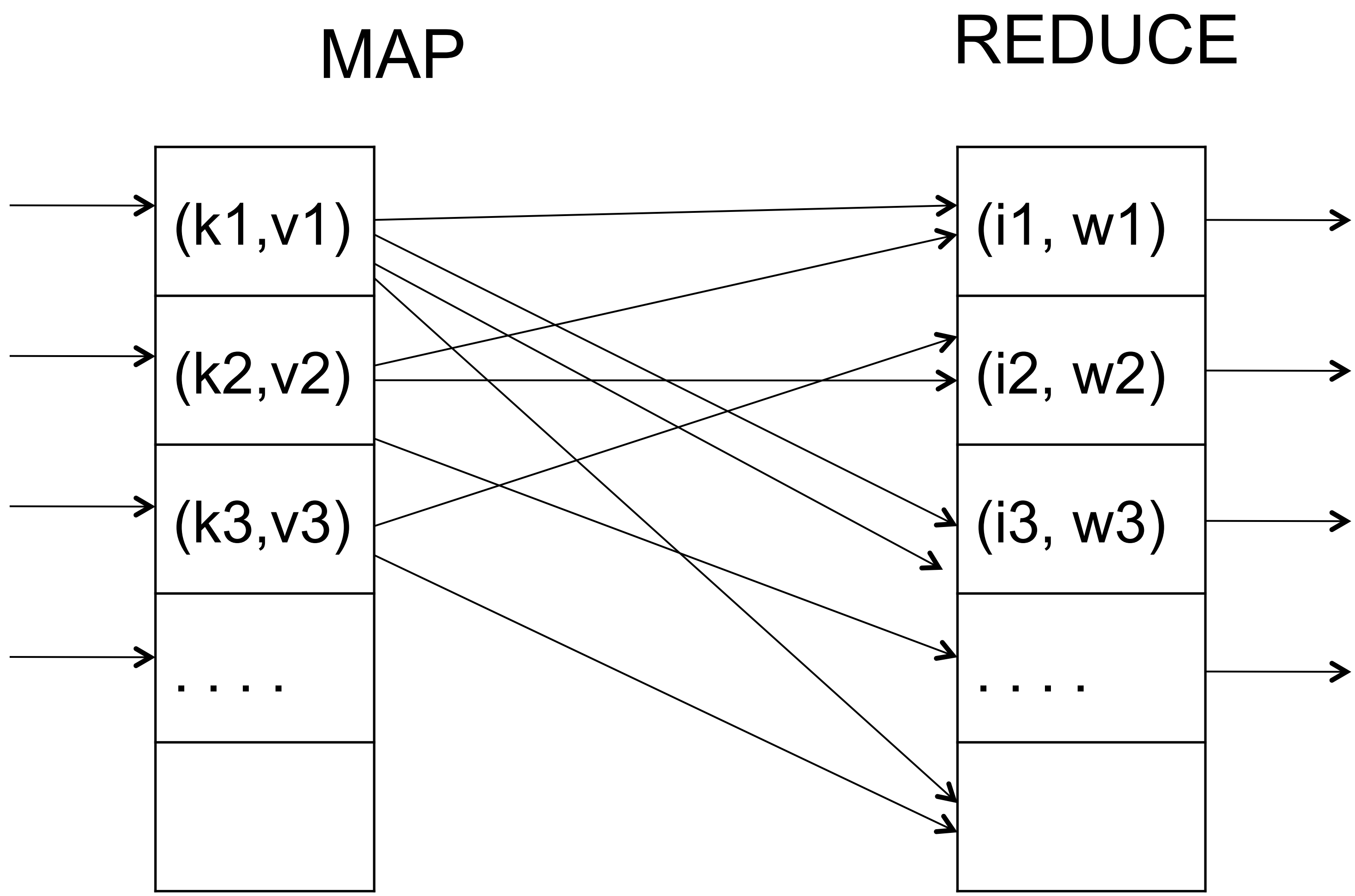
System groups all pairs with the same intermediate key, and passes the bag of values to the REDUCE function

Example

- Counting the number of occurrences of each word in a large collection of

```
map(String key, String value):
    // key: document name
    // value: document contents
    for each word w in value:
        EmitIntermediate(w, "1"):
```

```
reduce(String key, Iterator values):
    // key: a word
    // values: a list of counts
    int result = 0;
    for each v in values:
        result += ParseInt(v);
    Emit(AsString(result));
```


MAP
REDUCE
(k1,v1)
(k2,v2)
(k3,v3)
. . . .
(i1, w1)
(i2, w2)
(i3, w3)
. . . .

Map = GROUP BY,
Reduce = Aggregate

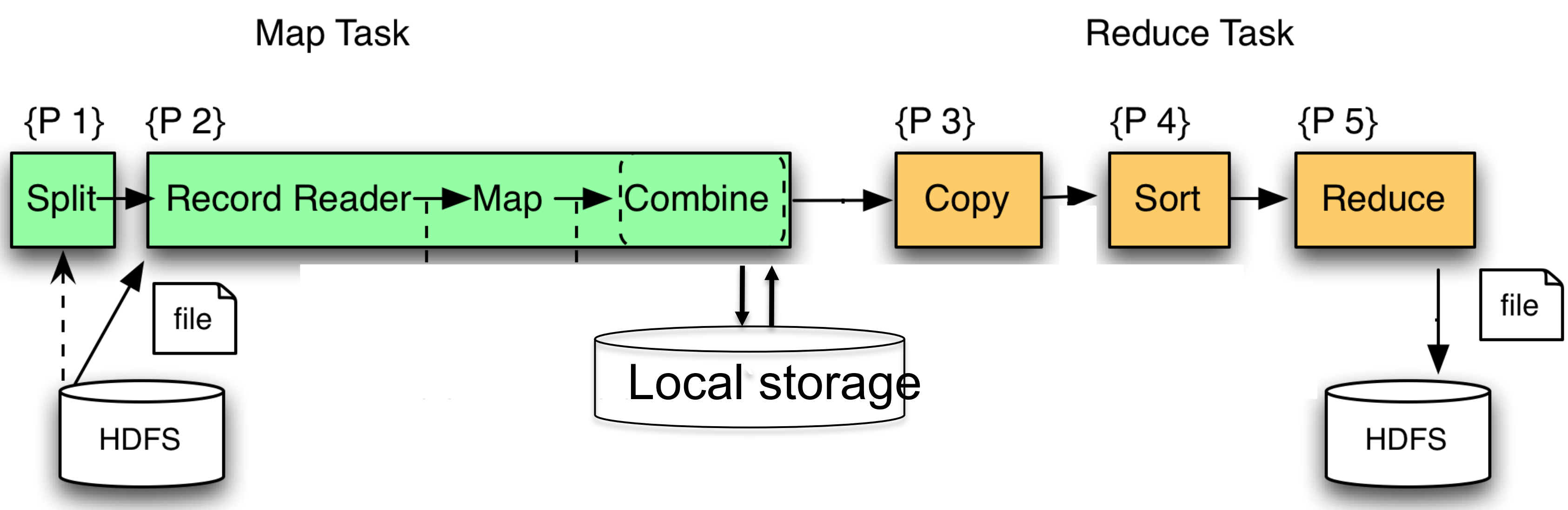
R(documentKey, word)

```
SELECT word, sum(1)
FROM R
GROUP BY word
```

Implementation

- There is one master node
- Master partitions input file into *M splits*, by key
- Master assigns *workers* (=servers) to the *M map tasks*, keeps track of their progress
- Workers write their output to local disk, partition into *R regions*
- Master assigns workers to the *R reduce tasks*
- Reduce workers read regions from the map workers' local disks

MR Phases



Map Task
Reduce Task
{P 1}
{P 2}
{P 3}
{P 4}
{P 5}
Split
Record Reader
Map
Combine
Copy
Sort
Reduce
file
HDFS
Local storage
file
HDFS

Interesting Implementation Details

- Worker failure:
  - Master pings workers periodically,
  - If down then reassigns its splits *to all other* workers → good load balance
- Choice of M and R:
  - Larger is better for load balancing
  - Limitation: master needs O(M×R) memory

Interesting Implementation Details

Backup tasks:

- *Straggler* = a machine that takes unusually long time to complete one of the last tasks. Eg:
  - Bad disk forces frequent correctable errors (30MB/s → 1MB/s)
  - The cluster scheduler has scheduled other tasks on that machine
- Stragglers are a main reason for slowdown
- Solution*: pre-emptive backup execution of the last few remaining in-progress tasks*

Map-Reduce Summary

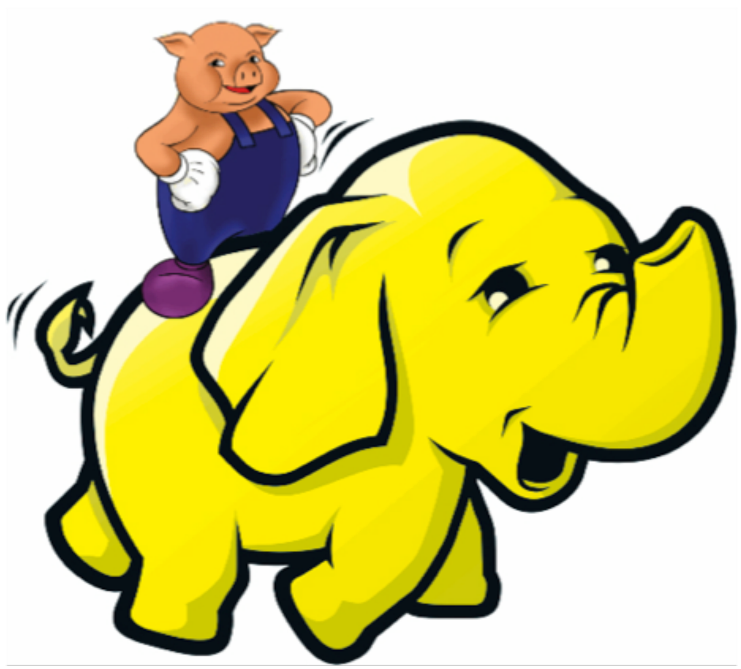
- Hides scheduling and parallelization details
- However, very limited queries
  - Difficult to write more complex tasks
  - Need multiple map-reduce operations
- Solution:

PIG-Latin !

Following Slides courtesy of: Alan Gates, Yahoo!Research

What is Pig?

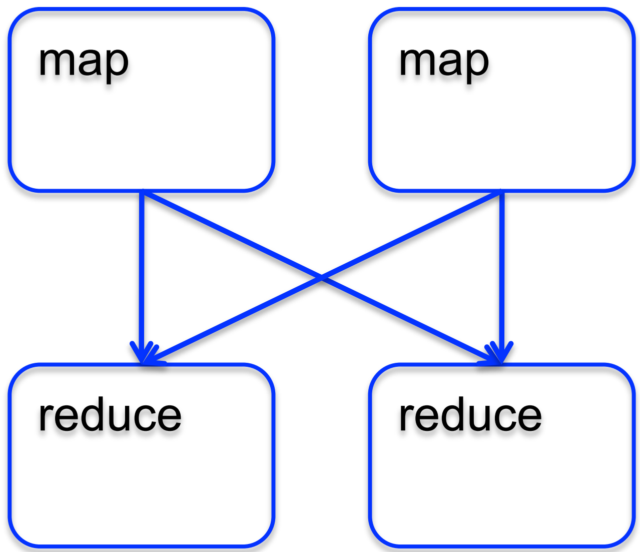
- An engine for executing programs on top of Hadoop
- It provides a language, Pig Latin, to specify these programs
- An Apache open source project
  http://hadoop.apache.org/pig/



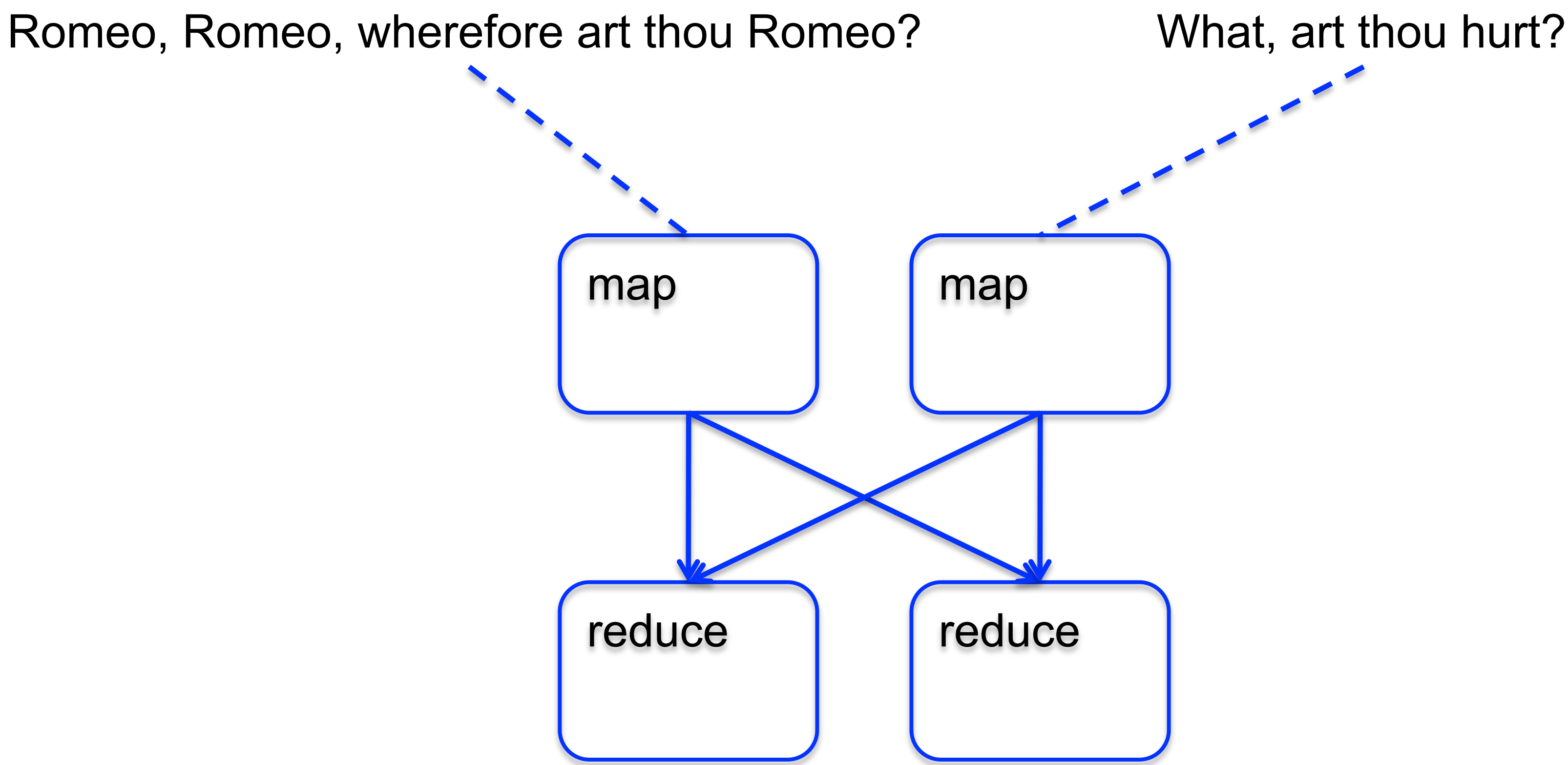
Map-Reduce

- Computation is moved to the data
- A simple yet powerful programming model
  - Map: every record handled individually
  - Shuffle: records collected by key
  - Reduce: key and iterator of all associated values
- User provides:
  - input and output (usually files)
  - map Java function
  - key to aggregate on
  - reduce Java function
- Opportunities for more control: partitioning, sorting, partial aggregations, etc.

Map Reduce Illustrated



Map Reduce Illustrated

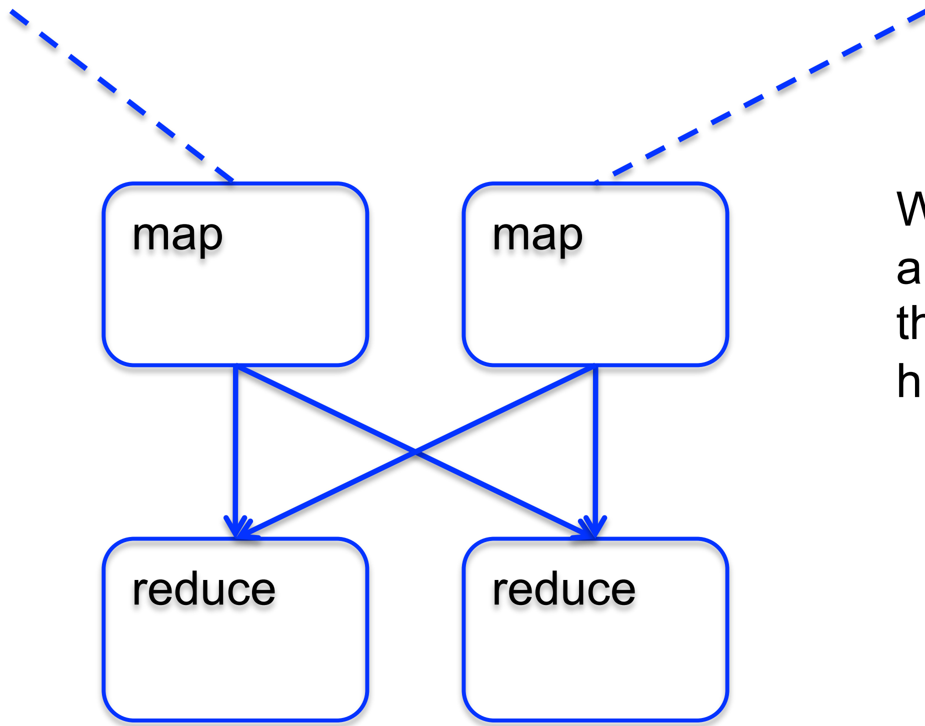


Map Reduce Illustrated

Romeo, Romeo, wherefore art thou Romeo?

What, art thou hurt?

Romeo, 1
Romeo, 1
wherefore, 1
art, 1
thou, 1
Romeo, 1

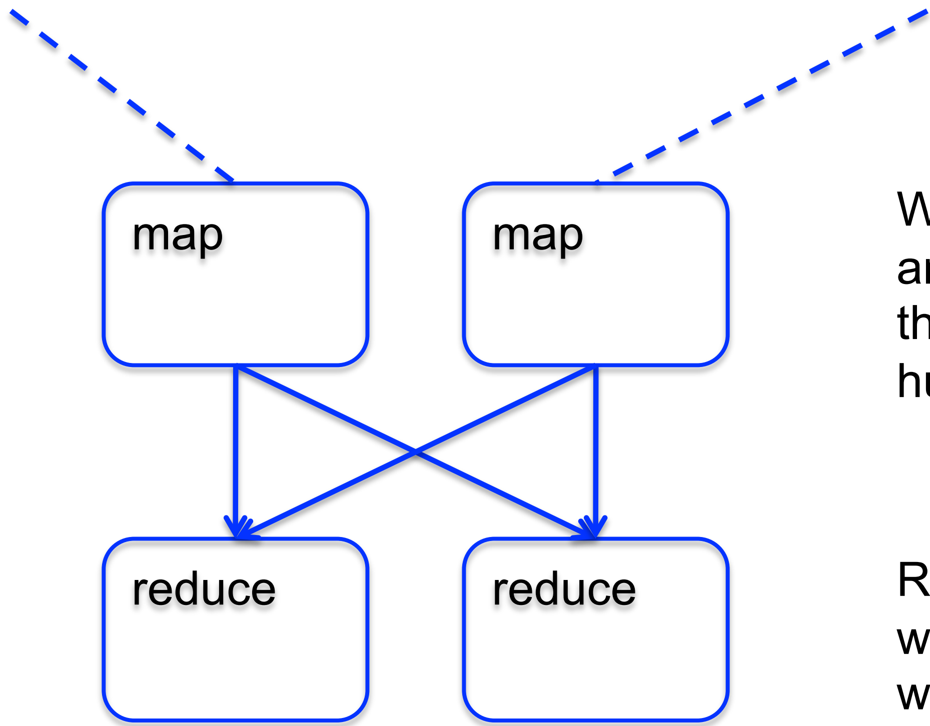


What, 1
art, 1
thou, 1
hurt, 1

Map Reduce Illustrated

Romeo, Romeo, wherefore art thou Romeo?

What, art thou hurt?



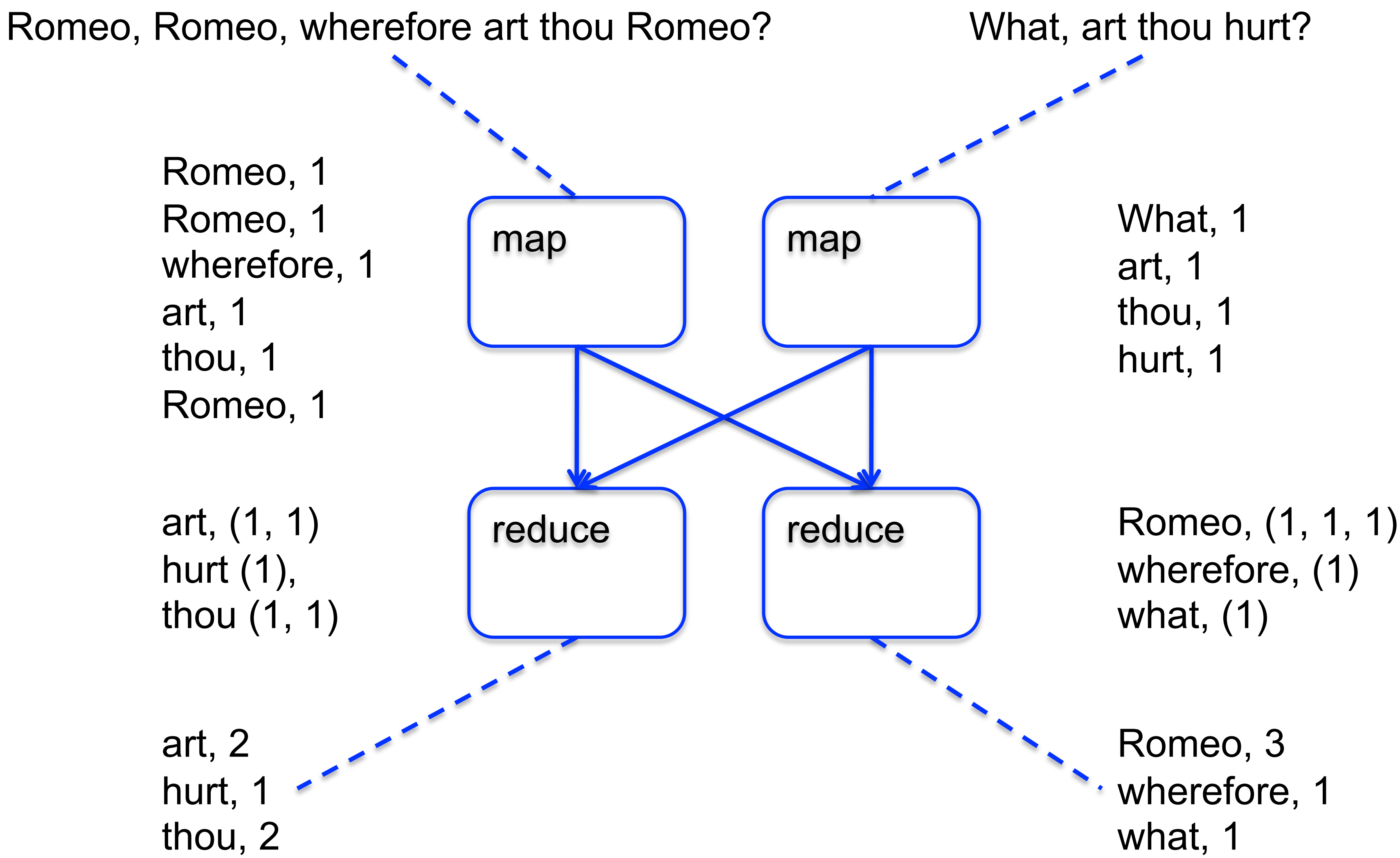
Romeo, 1
Romeo, 1
wherefore, 1
art, 1
thou, 1
Romeo, 1

What, 1
art, 1
thou, 1
hurt, 1

art, (1, 1)
hurt (1),
thou (1, 1)

Romeo, (1, 1, 1)
wherefore, (1)
what, (1)

Map Reduce Illustrated

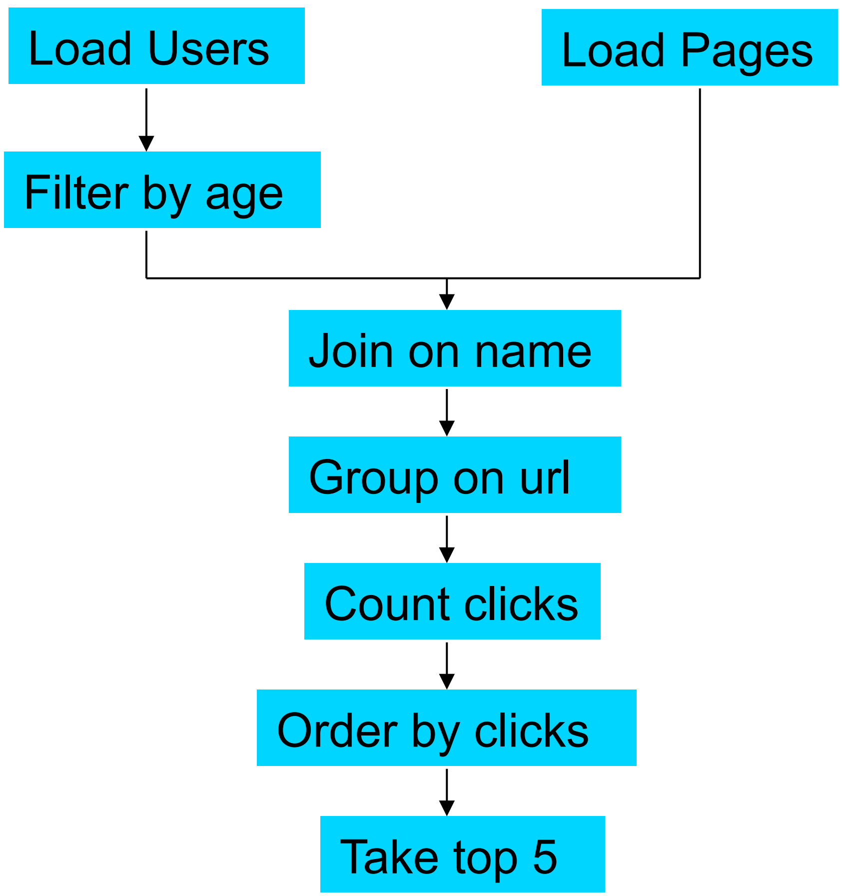


Making Parallelism Simple

- Sequential reads = good read speeds
- In large cluster failures are guaranteed; Map Reduce handles retries
- Good fit for batch processing applications that need to touch all your data:
  - data mining
  - model tuning
- Bad fit for applications that need to find one particular record
- Bad fit for applications that need to communicate between processes; oriented around independent units of work

Why use Pig?

Suppose you have user data in one file, website data in another, and you need to find the top 5 most visited sites by users aged 18 - 25.



In Map-Reduce

```java
import java.io.IOException;
import java.util.ArrayList;
import java.util.Iterator;
import java.util.List;

import org.apache.hadoop.fs.Path;
import org.apache.hadoop.io.LongWritable;
import org.apache.hadoop.io.Text;
import org.apache.hadoop.io.Writable;
import org.apache.hadoop.io.WritableComparable;
import org.apache.hadoop.mapred.FileInputFormat;
import org.apache.hadoop.mapred.FileOutputFormat;
import org.apache.hadoop.mapred.JobConf;
import org.apache.hadoop.mapred.KeyValueTextInputFormat;
import org.apache.hadoop.mapred.Mapper;
import org.apache.hadoop.mapred.MapReduceBase;
import org.apache.hadoop.mapred.OutputCollector;
import org.apache.hadoop.mapred.RecordReader;
import org.apache.hadoop.mapred.Reducer;
import org.apache.hadoop.mapred.Reporter;
import org.apache.hadoop.mapred.SequenceFileInputFormat;
import org.apache.hadoop.mapred.SequenceFileOutputFormat;
import org.apache.hadoop.mapred.TextInputFormat;
import org.apache.hadoop.mapred.jobcontrol.Job;
import org.apache.hadoop.mapred.jobcontrol.JobControl;
import org.apache.hadoop.mapred.lib.IdentityMapper;

public class MRExample {
    public static class LoadPages extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {

        public void map(LongWritable k, Text val,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // Pull the key out
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String key = line.substring(0, firstComma);
            String value = line.substring(firstComma + 1);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("1" + value);
            oc.collect(outKey, outVal);
        }
    }
    public static class LoadAndFilterUsers extends MapReduceBase
        implements Mapper<LongWritable, Text, Text, Text> {

        public void map(LongWritable k, Text val,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // Pull the key out
            String line = val.toString();
            int firstComma = line.indexOf(',');
            String value = line.substring(firstComma + 1);
            int age = Integer.parseInt(value);
            if (age < 18 || age > 25) return;
            String key = line.substring(0, firstComma);
            Text outKey = new Text(key);
            // Prepend an index to the value so we know which file
            // it came from.
            Text outVal = new Text("2" + value);
            oc.collect(outKey, outVal);
        }
    }
    public static class Join extends MapReduceBase
        implements Reducer<Text, Text, Text, Text> {

        public void reduce(Text key,
                Iterator<Text> iter,
                OutputCollector<Text, Text> oc,
                Reporter reporter) throws IOException {
            // For each value, figure out which file it's from and
store it
            // accordingly.
            List<String> first = new ArrayList<String>();
            List<String> second = new ArrayList<String>();

            while (iter.hasNext()) {
                Text t = iter.next();
                String value = t.toString();
                if (value.charAt(0) == '1')
first.add(value.substring(1));
                else second.add(value.substring(1));
                reporter.setStatus("OK");
            }

            // Do the cross product and collect the values
            for (String s1 : first) {
                for (String s2 : second) {
                    String outval = key + "," + s1 + "," + s2;
                    oc.collect(null, new Text(outval));
                    reporter.setStatus("OK");
                }
            }
        }
    }
    public static class LoadJoined extends MapReduceBase
        implements Mapper<Text, Text, Text, LongWritable> {

        public void map(
                Text k,
                Text val,
                OutputCollector<Text, LongWritable> oc,
                Reporter reporter) throws IOException {
            // Find the url
            String line = val.toString();
            int firstComma = line.indexOf(',');
            int secondComma = line.indexOf(',', firstComma);
            String key = line.substring(firstComma, secondComma);
            // drop the rest of the record, I don't need it anymore,
            // just pass a 1 for the combiner/reducer to sum instead.
            Text outKey = new Text(key);
            oc.collect(outKey, new LongWritable(1L));
        }
    }
    public static class ReduceUrls extends MapReduceBase
        implements Reducer<Text, LongWritable, WritableComparable,
Writable> {

        public void reduce(
                Text key,
                Iterator<LongWritable> iter,
                OutputCollector<WritableComparable, Writable> oc,
                Reporter reporter) throws IOException {
            // Add up all the values we see

            long sum = 0;
            while (iter.hasNext()) {
                sum += iter.next().get();
                reporter.setStatus("OK");
            }

            oc.collect(key, new LongWritable(sum));
        }
    }
    public static class LoadClicks extends MapReduceBase
        implements Mapper<WritableComparable, Writable, LongWritable,
Text> {

        public void map(
                WritableComparable key,
                Writable val,
                OutputCollector<LongWritable, Text> oc,
                Reporter reporter) throws IOException {
            oc.collect((LongWritable)val, (Text)key);
        }
    }
    public static class LimitClicks extends MapReduceBase
        implements Reducer<LongWritable, Text, LongWritable, Text> {

        int count = 0;
        public void reduce(
            LongWritable key,
            Iterator<Text> iter,
            OutputCollector<LongWritable, Text> oc,
            Reporter reporter) throws IOException {

            // Only output the first 100 records
            while (count < 100 && iter.hasNext()) {
                oc.collect(key, iter.next());
                count++;
            }
        }
    }
    public static void main(String[] args) throws IOException {
        JobConf lp = new JobConf(MRExample.class);
        lp.setJobName("Load Pages");
        lp.setInputFormat(TextInputFormat.class);
        lp.setOutputKeyClass(Text.class);
        lp.setOutputValueClass(Text.class);
        lp.setMapperClass(LoadPages.class);
        FileInputFormat.addInputPath(lp, new
Path("/user/gates/pages"));
        FileOutputFormat.setOutputPath(lp,
            new Path("/user/gates/tmp/indexed_pages"));
        lp.setNumReduceTasks(0);
        Job loadPages = new Job(lp);

        JobConf lfu = new JobConf(MRExample.class);
        lfu.setJobName("Load and Filter Users");
        lfu.setInputFormat(TextInputFormat.class);
        lfu.setOutputKeyClass(Text.class);
        lfu.setOutputValueClass(Text.class);
        lfu.setMapperClass(LoadAndFilterUsers.class);
        FileInputFormat.addInputPath(lfu, new
Path("/user/gates/users"));
        FileOutputFormat.setOutputPath(lfu,
            new Path("/user/gates/tmp/filtered_users"));
        lfu.setNumReduceTasks(0);
        Job loadUsers = new Job(lfu);

        JobConf join = new JobConf(MRExample.class);
        join.setJobName("Join Users and Pages");
        join.setInputFormat(KeyValueTextInputFormat.class);
        join.setOutputKeyClass(Text.class);
        join.setOutputValueClass(Text.class);
        join.setMapperClass(IdentityMapper.class);
        join.setReducerClass(Join.class);
        FileInputFormat.addInputPath(join, new
Path("/user/gates/tmp/indexed_pages"));
        FileInputFormat.addInputPath(join, new
Path("/user/gates/tmp/filtered_users"));
        FileOutputFormat.setOutputPath(join, new
Path("/user/gates/tmp/joined"));
        join.setNumReduceTasks(50);
        Job joinJob = new Job(join);
        joinJob.addDependingJob(loadPages);
        joinJob.addDependingJob(loadUsers);

        JobConf group = new JobConf(MRExample.class);
        group.setJobName("Group URLs");
        group.setInputFormat(KeyValueTextInputFormat.class);
        group.setOutputKeyClass(Text.class);
        group.setOutputValueClass(LongWritable.class);
        group.setOutputFormat(SequenceFileOutputFormat.class);
        group.setMapperClass(LoadJoined.class);
        group.setCombinerClass(ReduceUrls.class);
        group.setReducerClass(ReduceUrls.class);
        FileInputFormat.addInputPath(group, new
Path("/user/gates/tmp/joined"));
        FileOutputFormat.setOutputPath(group, new
Path("/user/gates/tmp/grouped"));
        group.setNumReduceTasks(50);
        Job groupJob = new Job(group);
        groupJob.addDependingJob(joinJob);

        JobConf top100 = new JobConf(MRExample.class);
        top100.setJobName("Top 100 sites");
        top100.setInputFormat(SequenceFileInputFormat.class);
        top100.setOutputKeyClass(LongWritable.class);
        top100.setOutputValueClass(Text.class);
        top100.setOutputFormat(SequenceFileOutputFormat.class);
        top100.setMapperClass(LoadClicks.class);
        top100.setCombinerClass(LimitClicks.class);
        top100.setReducerClass(LimitClicks.class);
        FileInputFormat.addInputPath(top100, new
Path("/user/gates/tmp/grouped"));
        FileOutputFormat.setOutputPath(top100, new
Path("/user/gates/top100sitesforusers18to25"));
        top100.setNumReduceTasks(1);
        Job limit = new Job(top100);
        limit.addDependingJob(groupJob);

        JobControl jc = new JobControl("Find top 100 sites for users
18 to 25");
        jc.addJob(loadPages);
        jc.addJob(loadUsers);
        jc.addJob(joinJob);
        jc.addJob(groupJob);
        jc.addJob(limit);
        jc.run();
    }
}
```

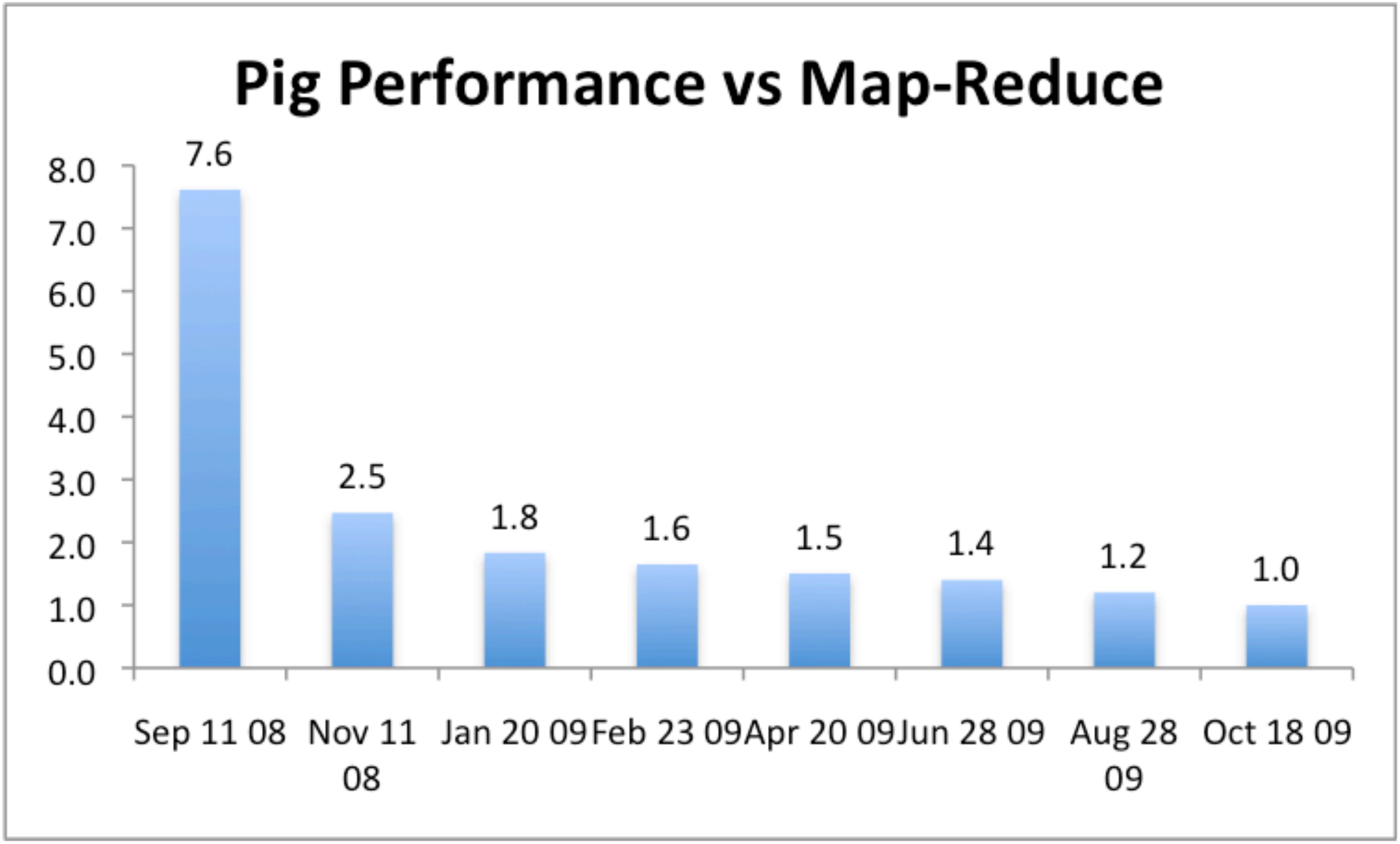
170 lines of code, 4 hours to write

In Pig Latin

```
Users = load 'users' as (name, age);
Fltrd = filter Users by
        age >= 18 and age <= 25;
Pages = load 'pages' as (user, url);
Jnd = join Fltrd by name, Pages by user;
Grpd = group Jnd by url;
Smmd = foreach Grpd generate group,
       COUNT(Jnd) as clicks;
Srtd = order Smmd by clicks desc;
Top5 = limit Srtd 5;
store Top5 into 'top5sites';
```

9 lines of code, 15 minutes to write

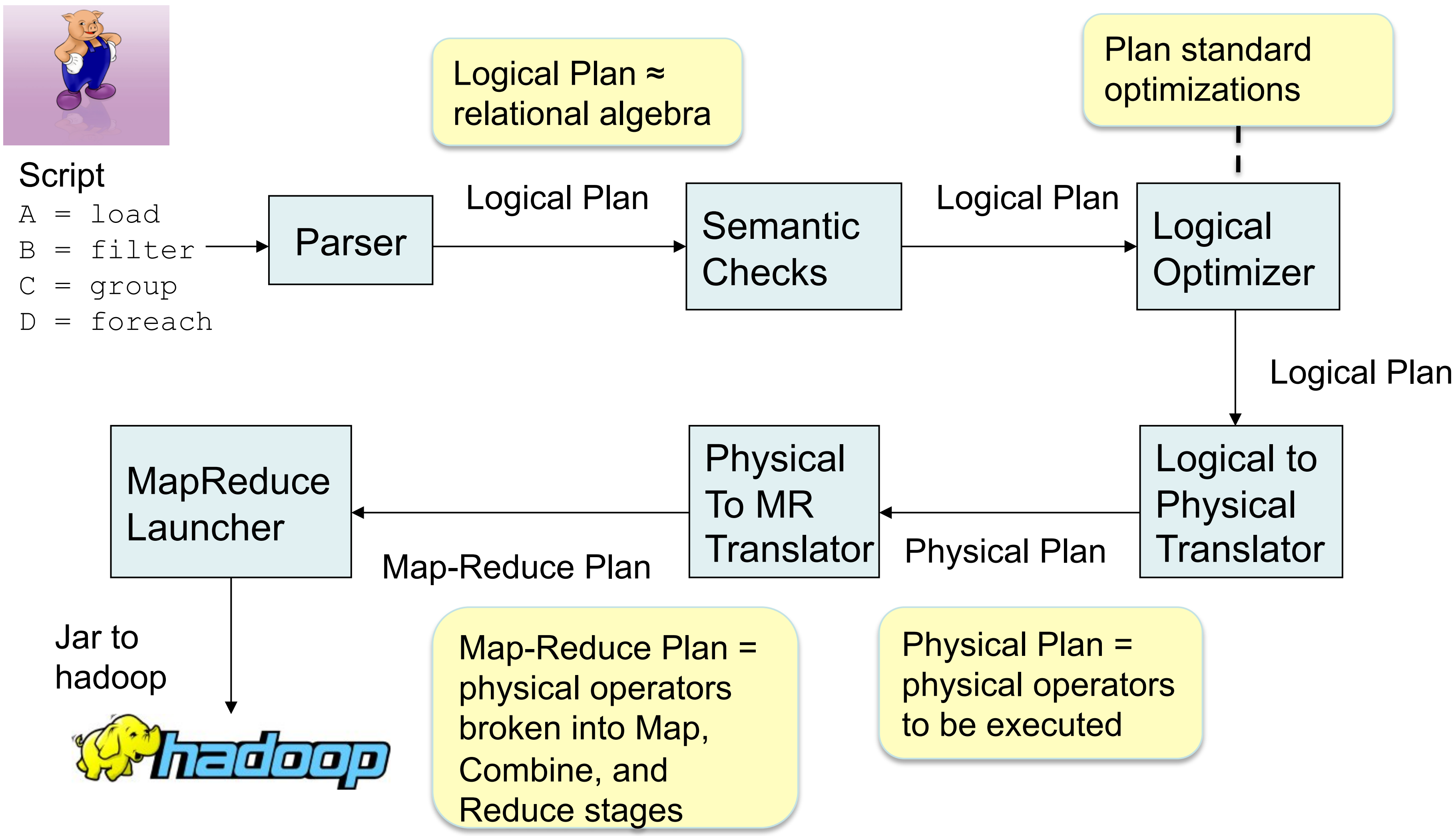
But can it fly?



Essence of Pig

- Map-Reduce is too low a level to program, SQL too high
- Pig Latin, a language intended to sit between the two:
  - Imperative
  - Provides standard relational transforms (join, sort, etc.)
  - Schemas are optional, used when available, can be defined at runtime
  - User Defined Functions are first class citizens
  - Opportunities for advanced optimizer but optimizations by programmer also possible

How It Works

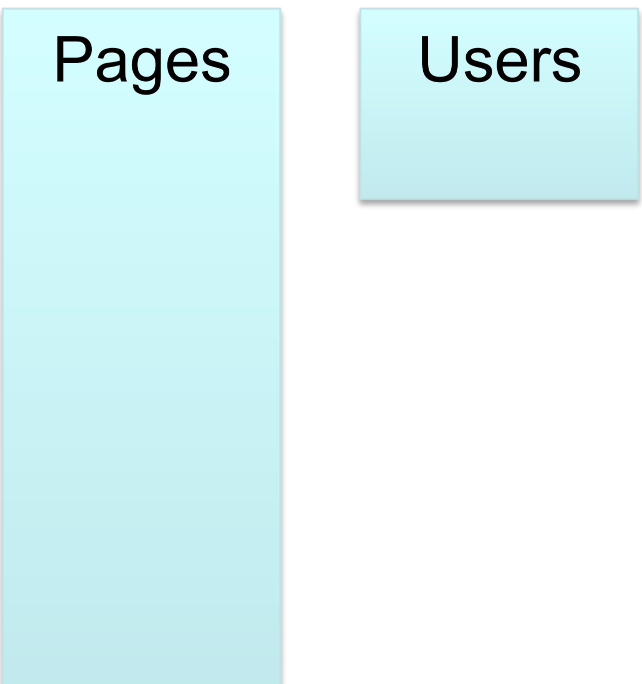

Script
A = load
B = filter
C = group
D = foreach
Parser
Logical Plan ≈ relational algebra
Logical Plan
Semantic Checks
Logical Plan
Plan standard optimizations
Logical Optimizer
Logical Plan
Logical to Physical Translator
Physical Plan
Physical To MR Translator
Map-Reduce Plan
MapReduce Launcher
Jar to hadoop
hadoop
Map-Reduce Plan = physical operators broken into Map, Combine, and Reduce stages
Physical Plan = physical operators to be executed

Cool Things We've Added In the Last Year

- Multiquery – Ability to combine multiple group bys into a single MR job (0.3)
- Merge join – If data is already sorted on join key, do join via merge in map phase (0.4)
- Skew join – Hash join for data with skew in join key. Allows splitting of key across multiple reducers to handle skew. (0.4)
- Zebra – Contrib project that provides columnar storage of data (0.4)
- Rework of Load and Store functions to make them much easier to write (0.7, branched but not released)
- Owl, a metadata service for the grid (committed, will be released in 0.8).

Fragment Replicate Join

Aka
“Broakdcast Join”



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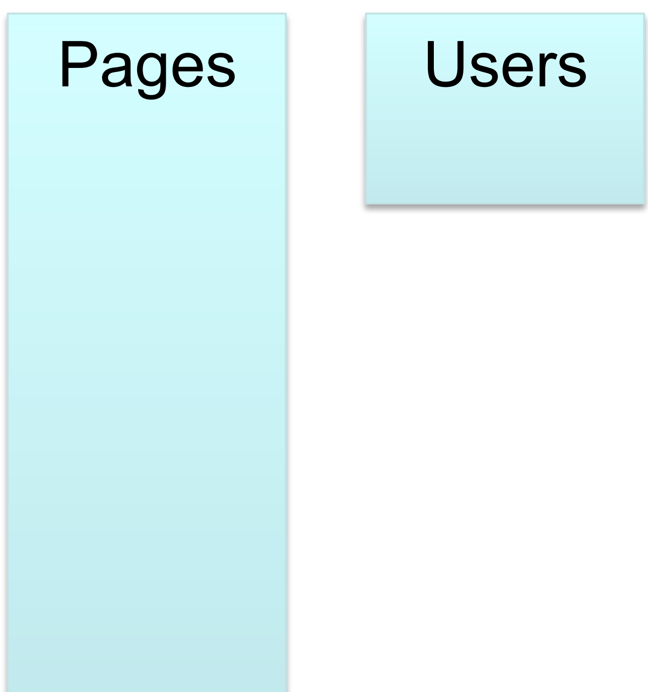
```



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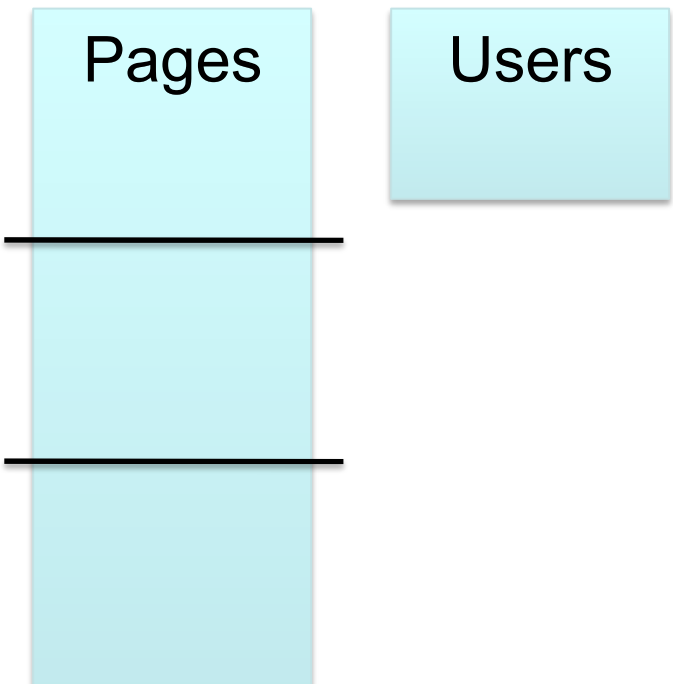

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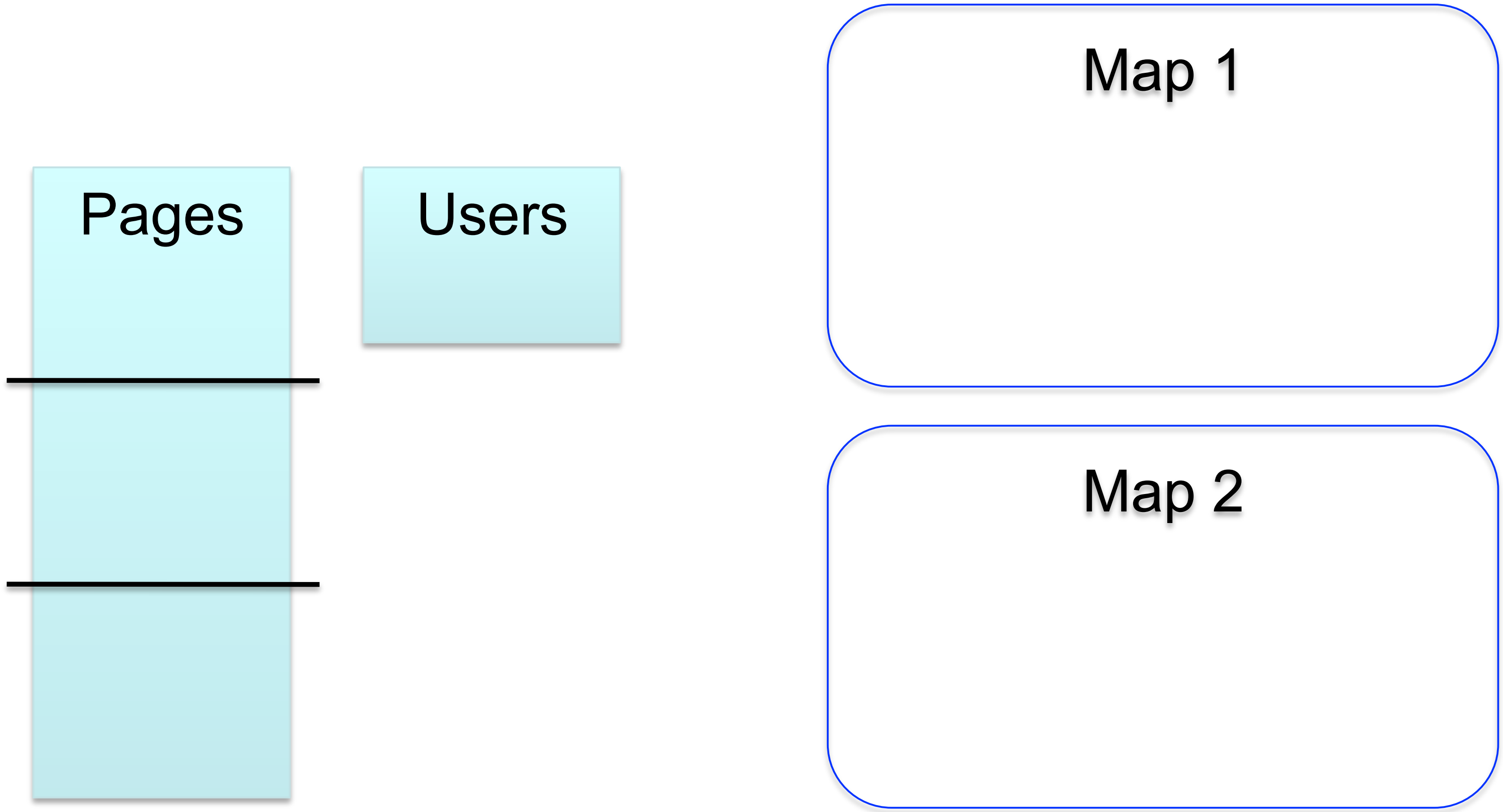

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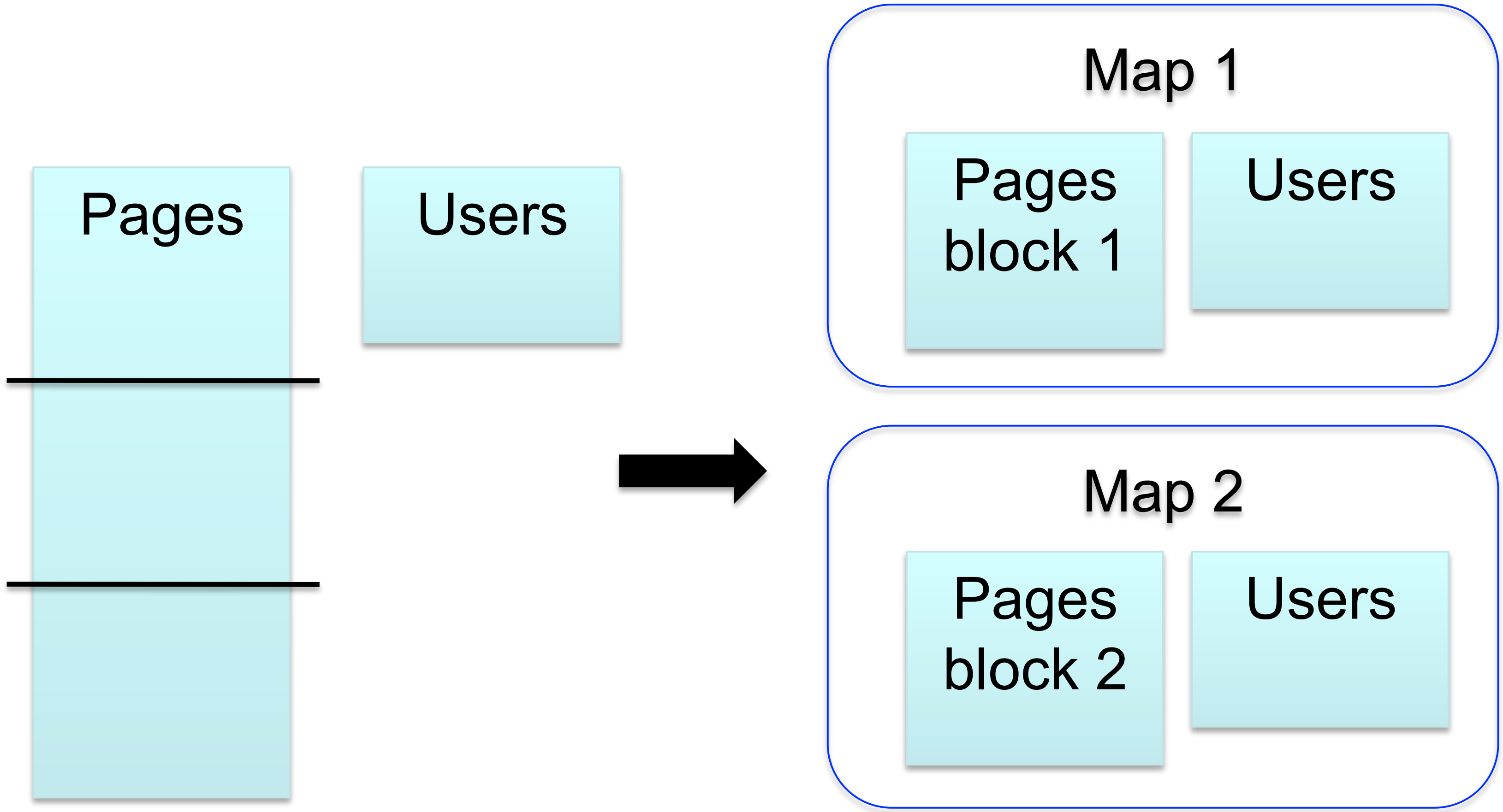
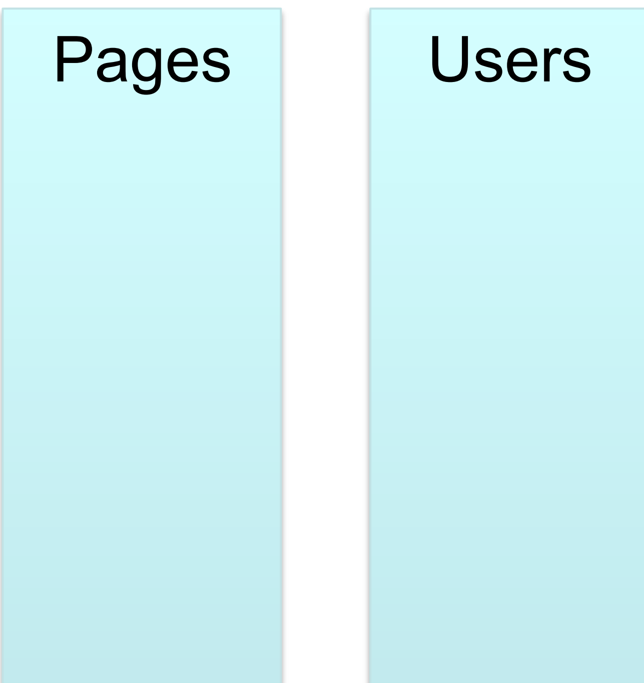


Hash Join



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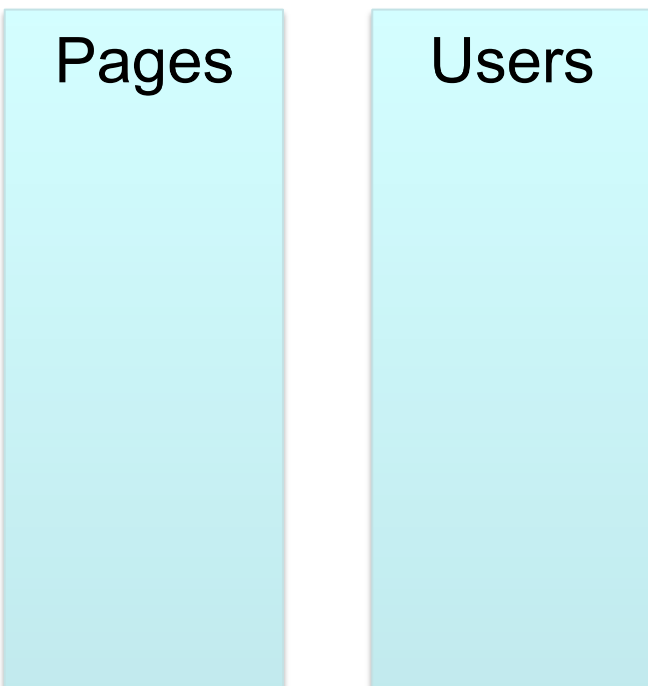

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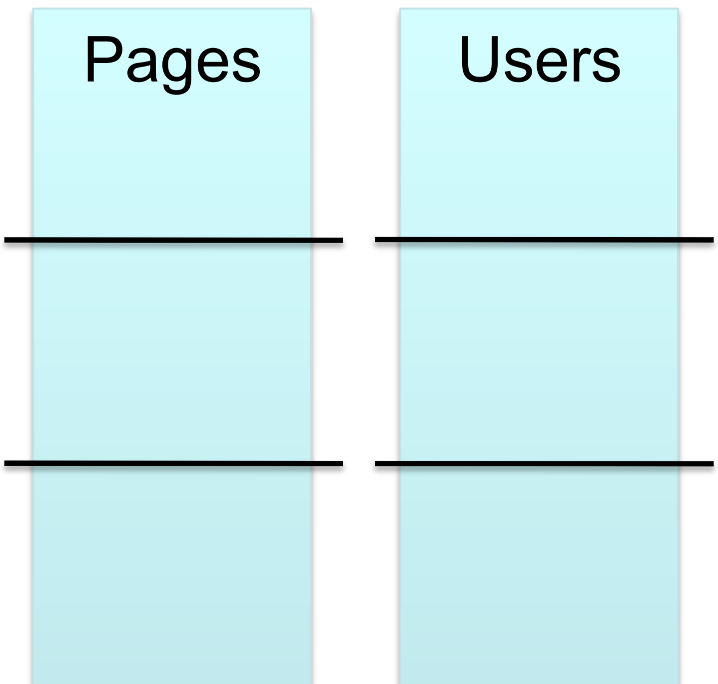

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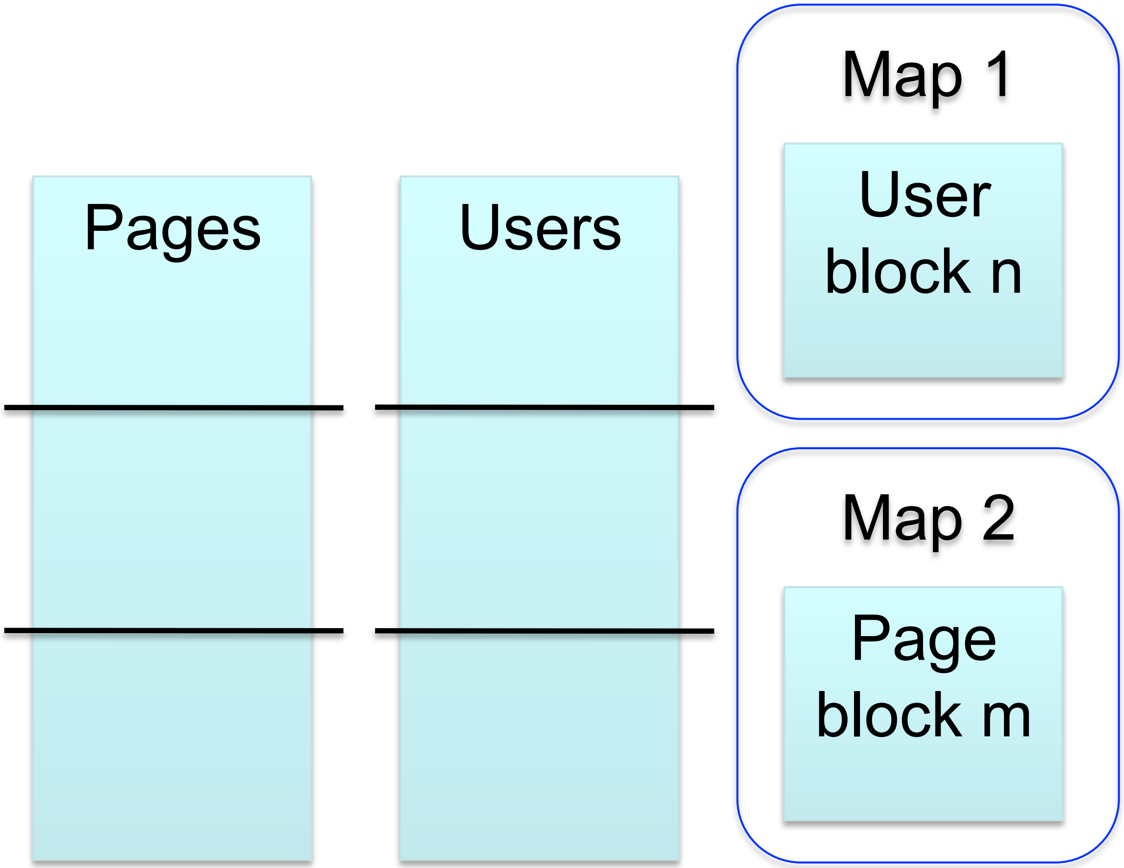

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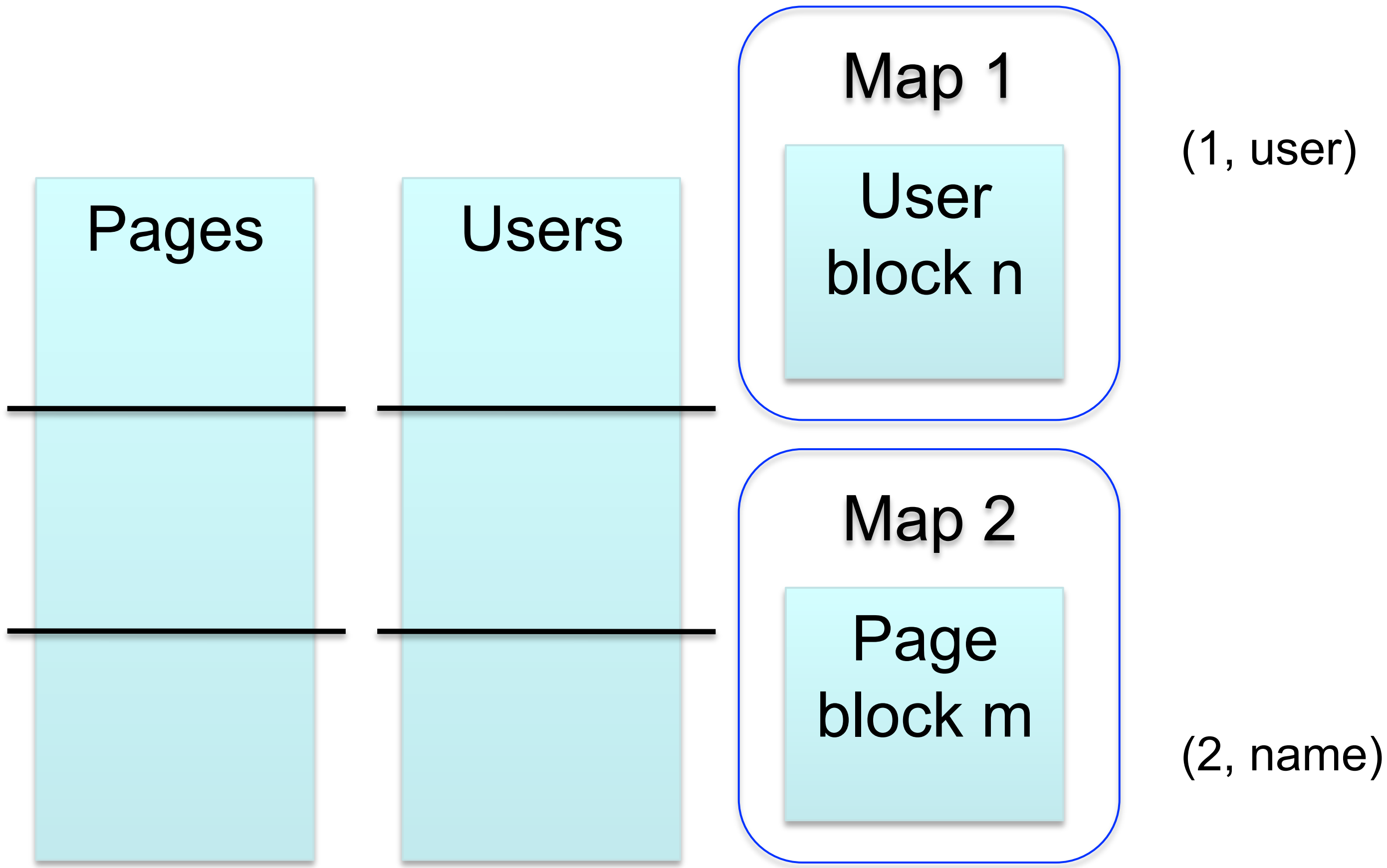

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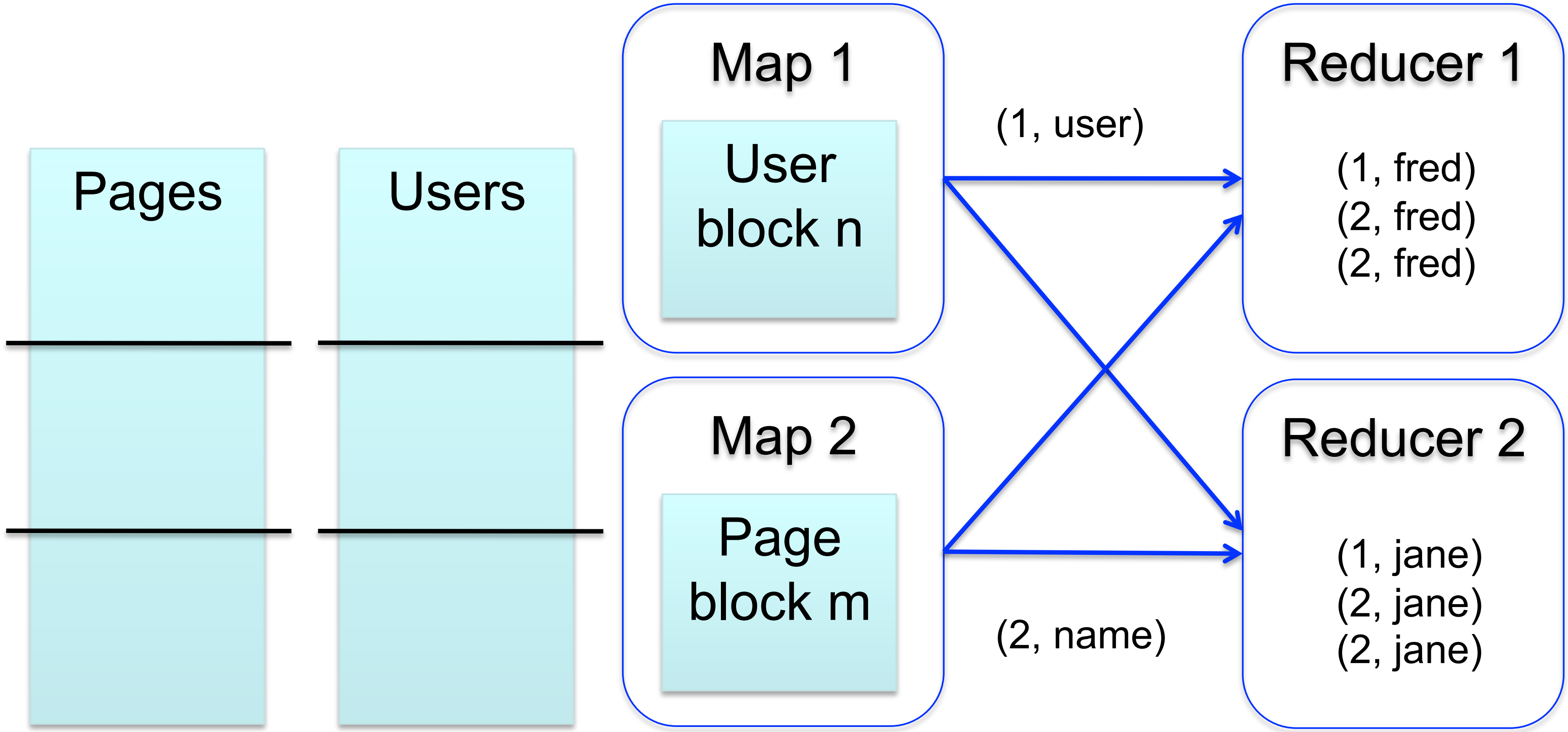

Skew Join

Pages

Users

Skew Join

```
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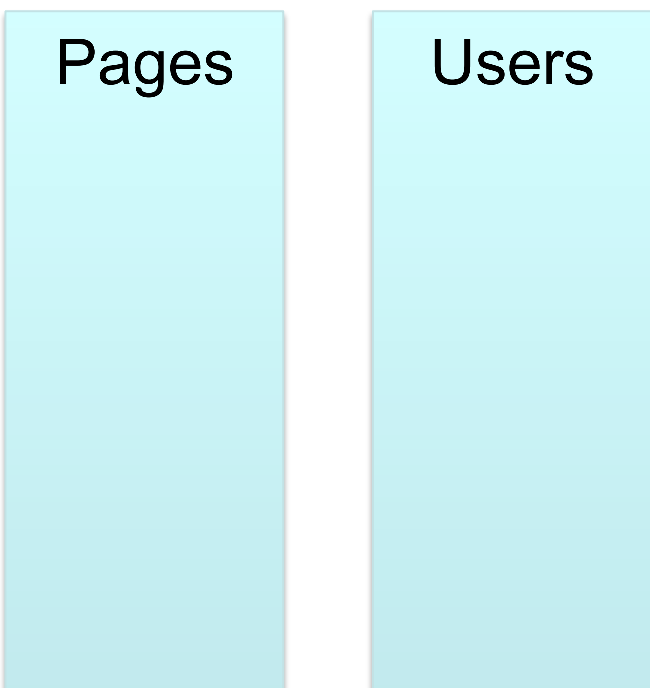
```



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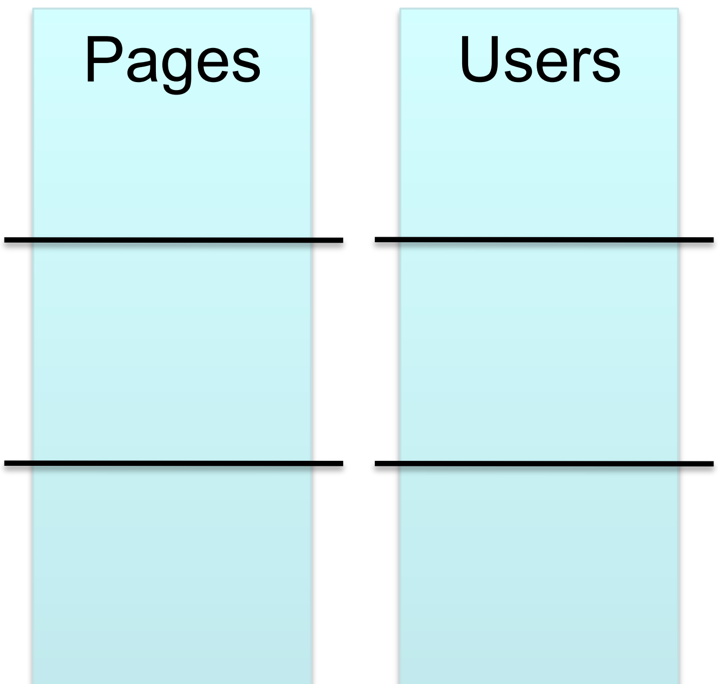

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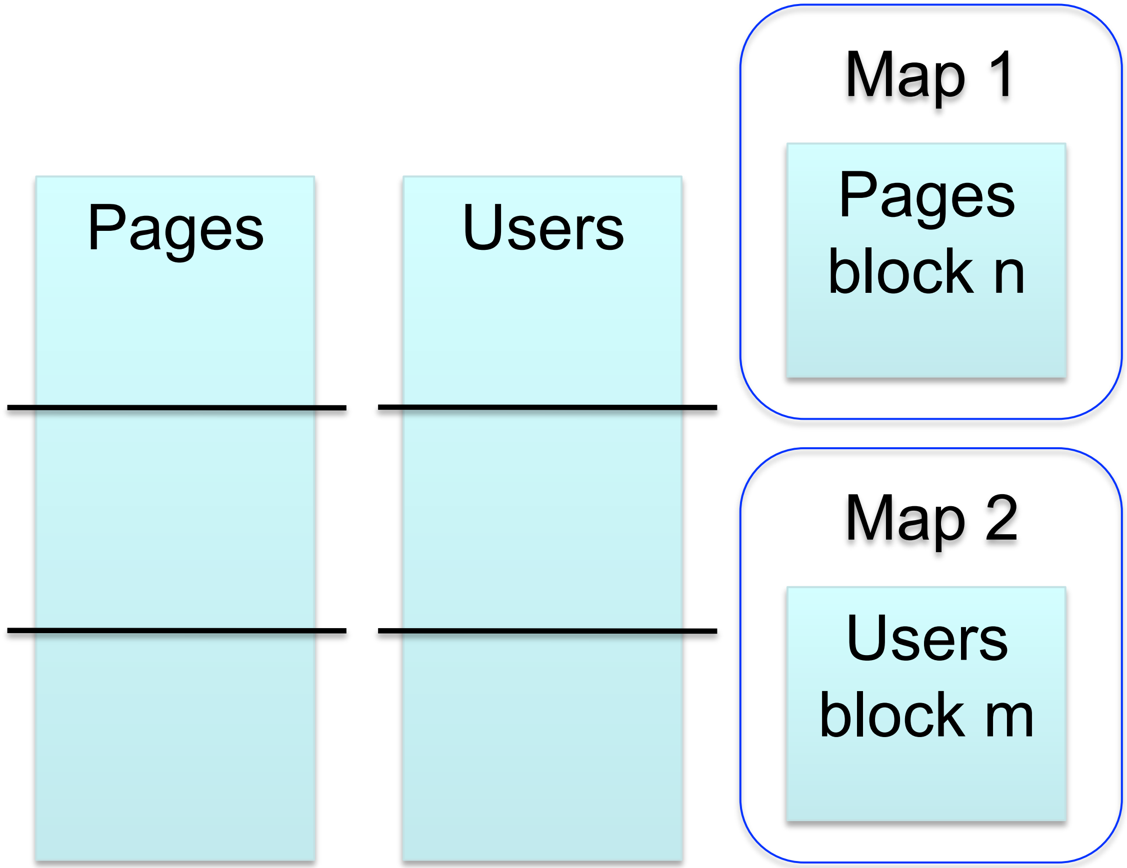

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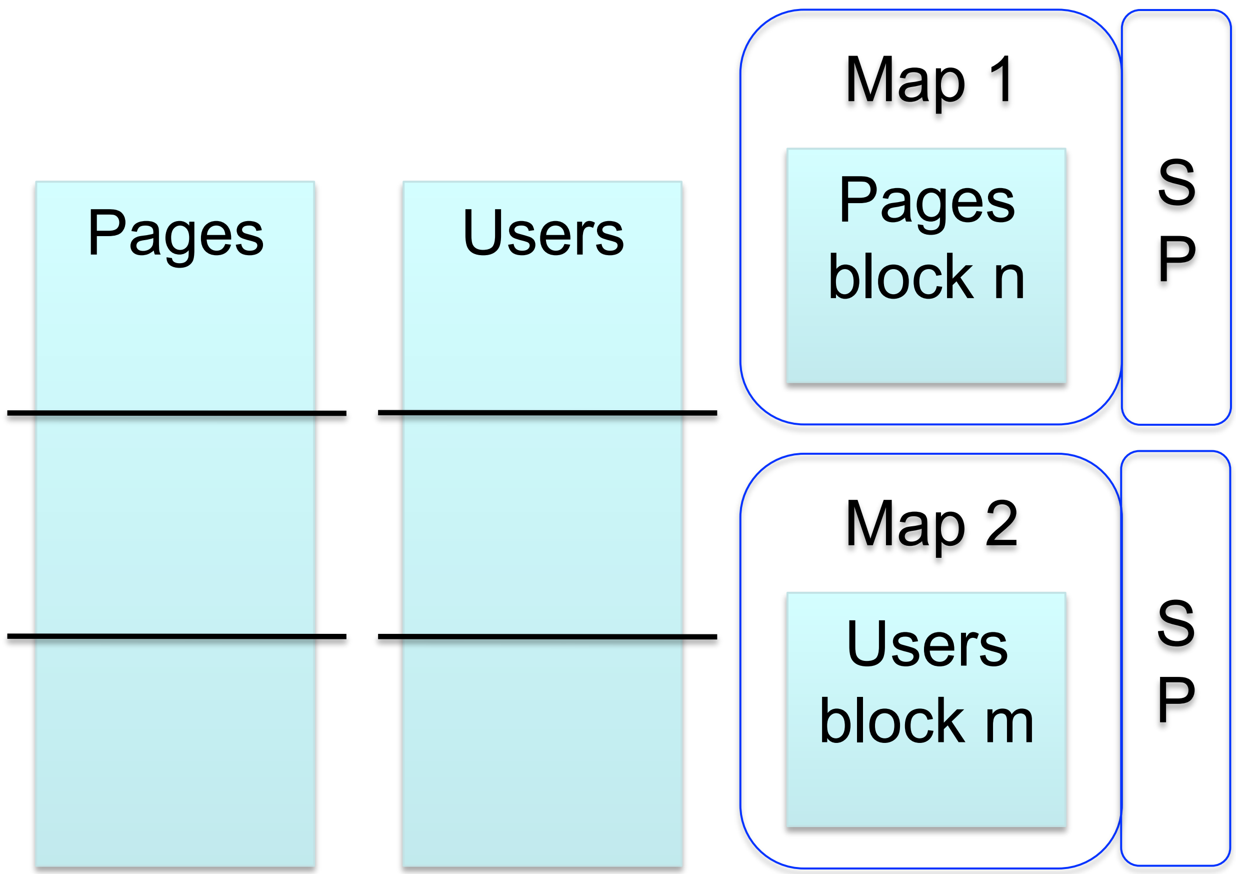

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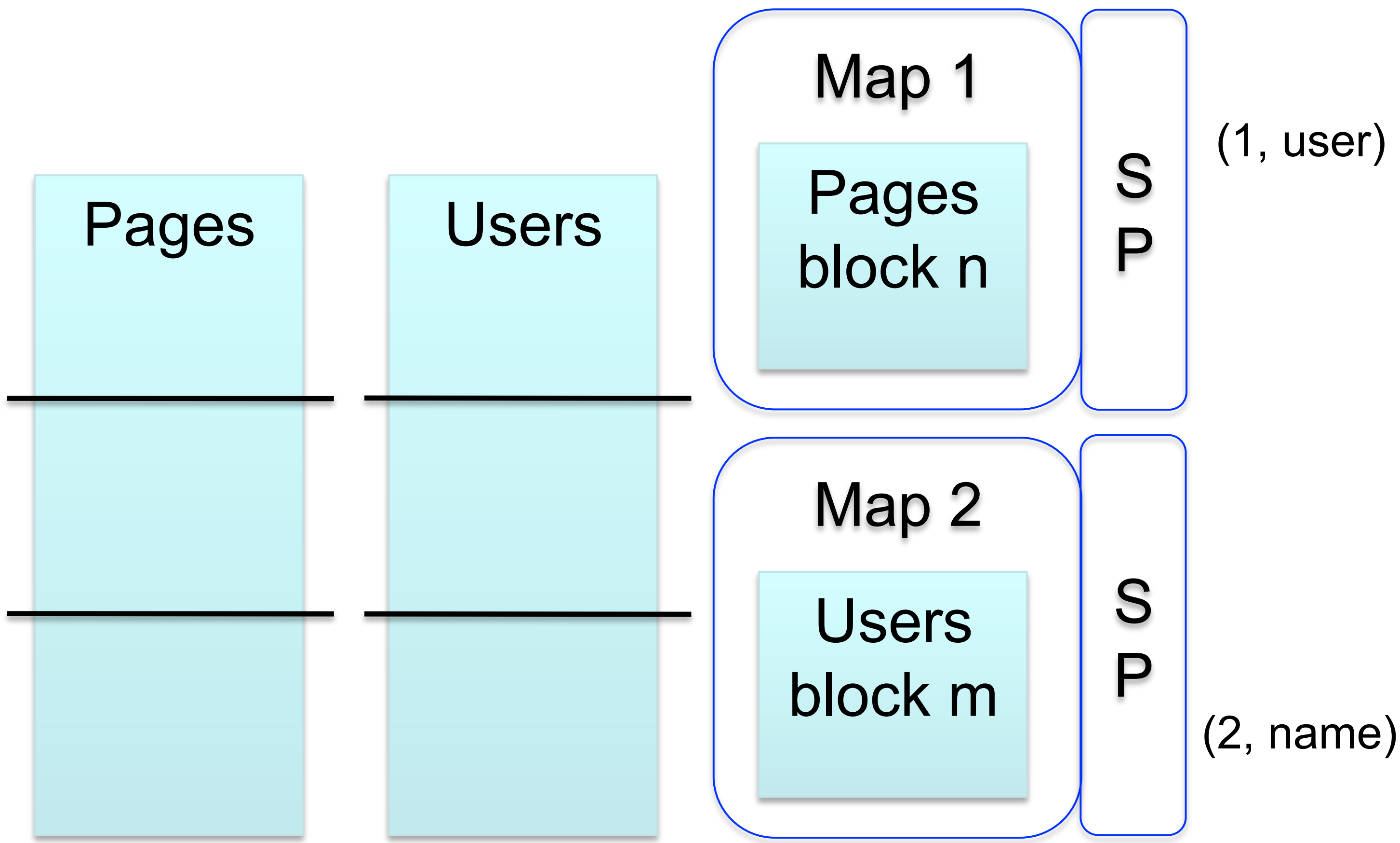

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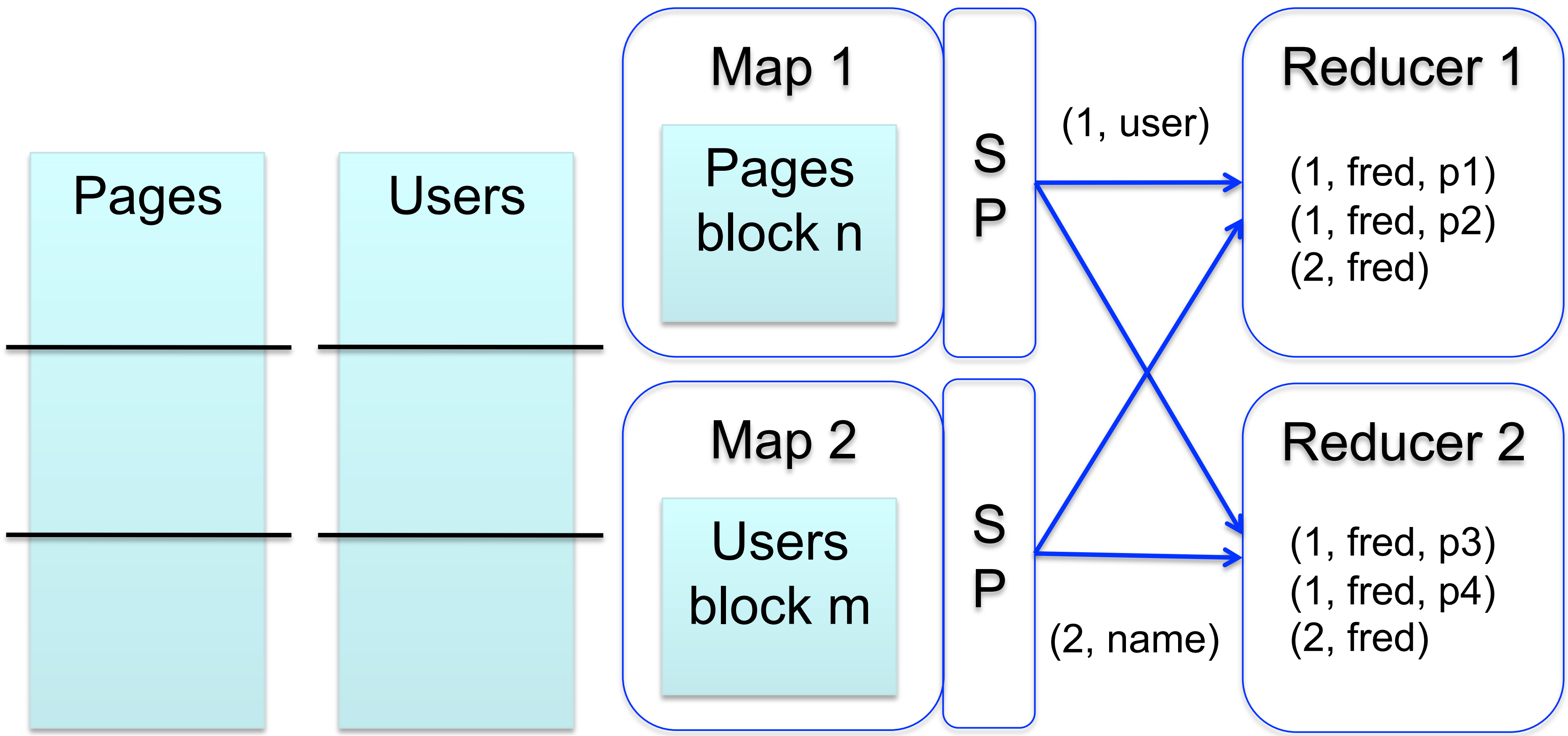
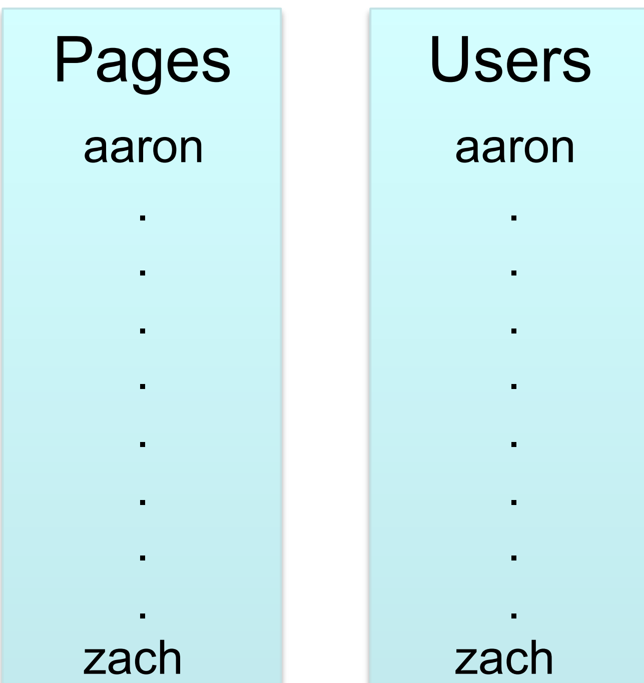


Merge Join

Pages	Users
aaron	aaron
.	.
.	.
.	.
.	.
.	.
.	.
.	.
.	.
zach	zach

Merge Join

```
Users = load 'users' as (name, age);
Pages = load 'pages' as (user, url);
Jnd = join Pages by user, Users by name using "merge";
```



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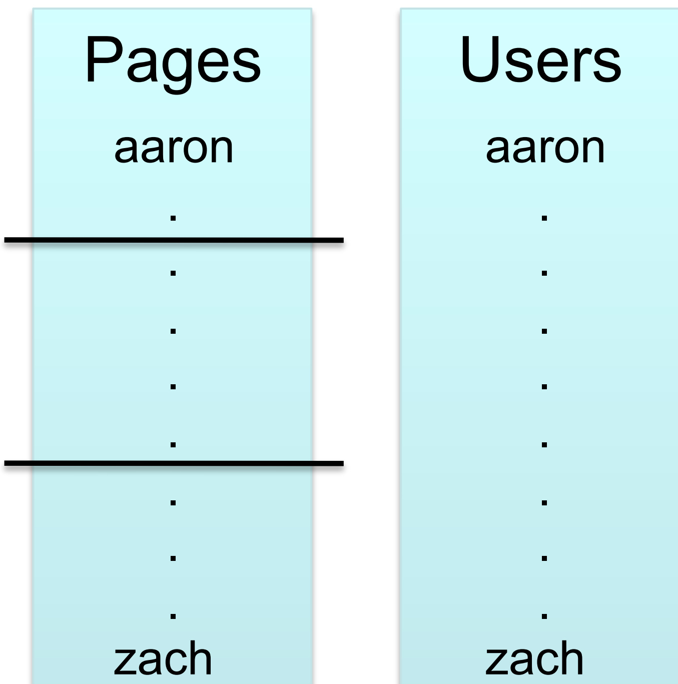

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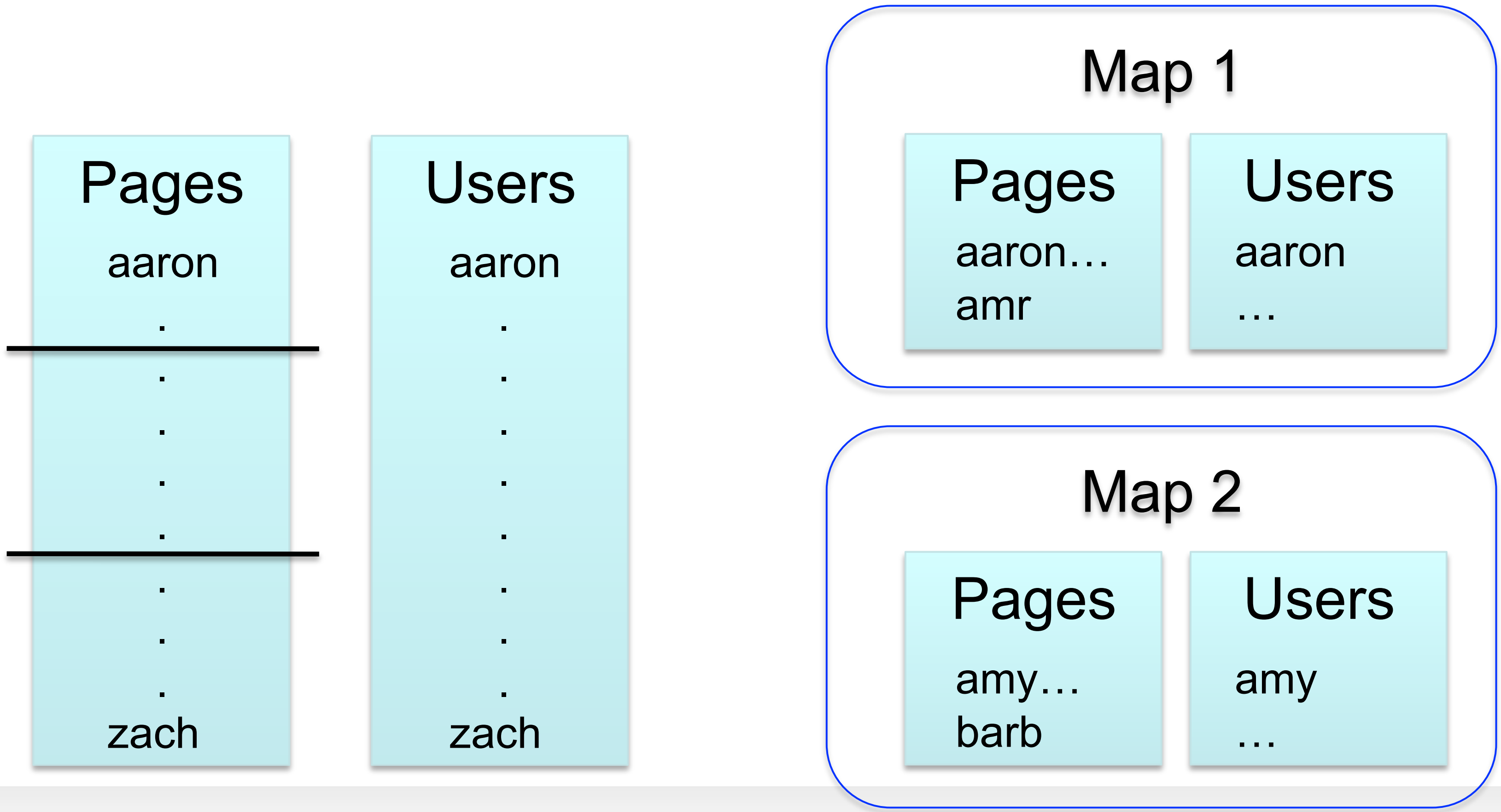
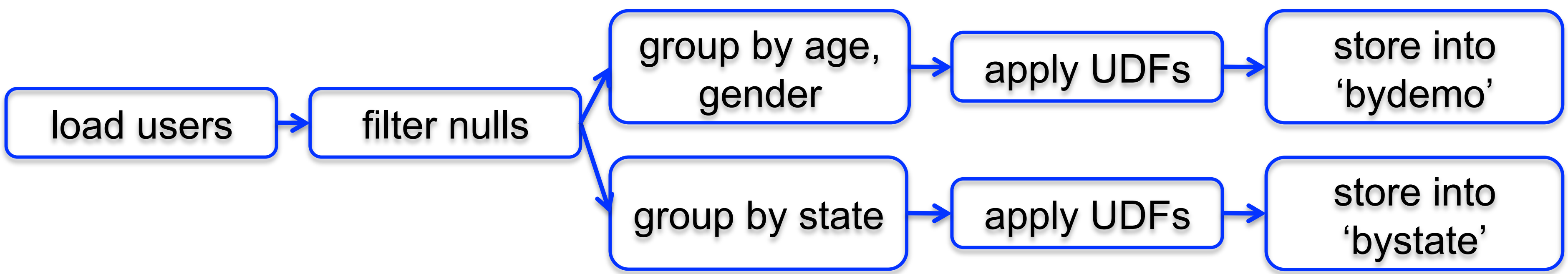
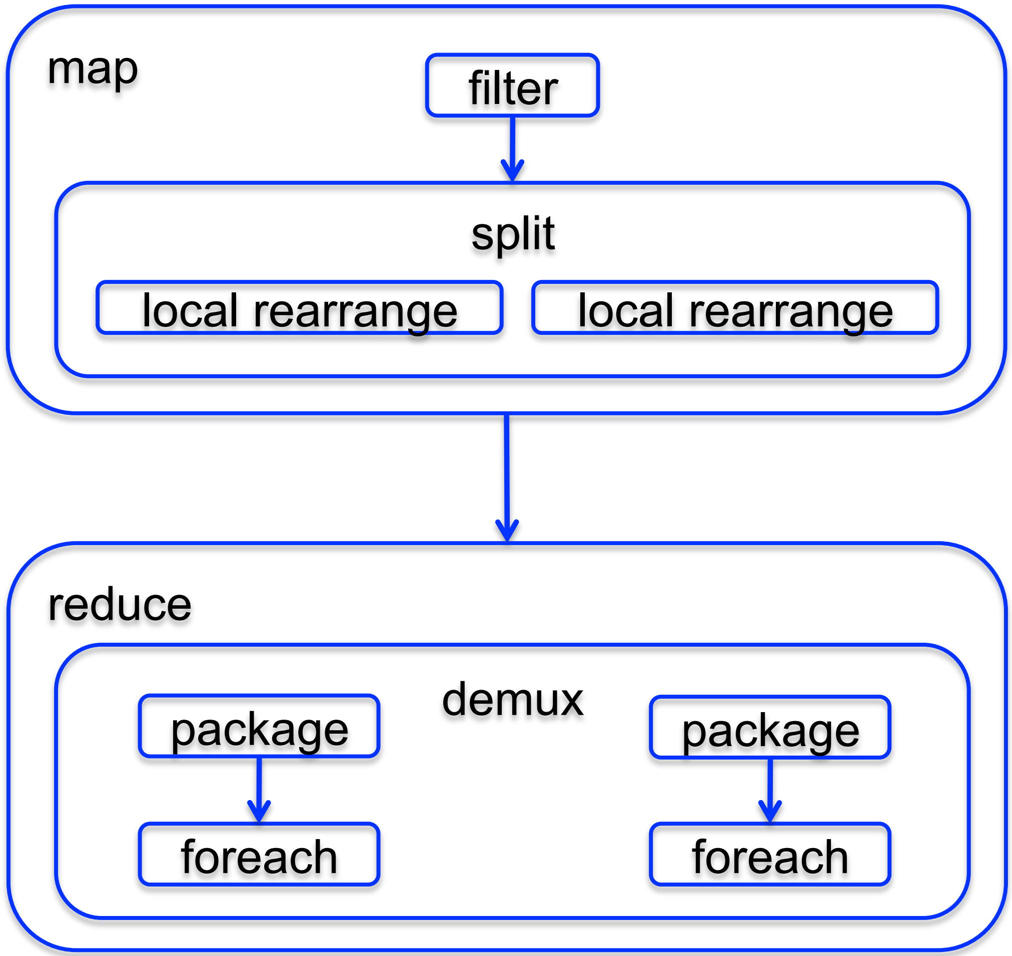


Multi-store script

```
A = load ‘users’ as (name, age, gender,
      city, state);
B = filter A by name is not null;
C1 = group B by age, gender;
D1 = foreach C1 generate group, COUNT(B);
store D into ‘bydemo’;
C2= group B by state;
D2 = foreach C2 generate group, COUNT(B);
store D2 into ‘bystate’;
```



Multi-Store Map-Reduce Plan



What are people doing with Pig

- At Yahoo ~70% of Hadoop jobs are Pig jobs
- Being used at Twitter, LinkedIn, and other companies
- Available as part of Amazon EMR web service and Cloudera Hadoop distribution
- What users use Pig for:
  - Search infrastructure
  - Ad relevance
  - Model training
  - User intent analysis
  - Web log processing
  - Image processing
  - Incremental processing of large data sets

What We're Working on this Year

- Optimizer rewrite
- Integrating Pig with metadata
- Usability – our current error messages might as well be written in actual Latin
- Automated usage info collection
- UDFs in python

Research Opportunities

- Cost based optimization – how does current RDBMS technology carry over to MR world?
- Memory Usage – given that data processing is very memory intensive and Java offers poor control of memory usage, how can Pig be written to use memory well?
- Automated Hadoop Tuning – Can Pig figure out how to configure Hadoop to best run a particular script?
- Indices, materialized views, etc. – How do these traditional RDBMS tools fit into the MR world?
- Human time queries – Analysts want access to the petabytes of data available via Hadoop, but they don’t want to wait hours for their jobs to finish; can Pig find a way to answer analysts question in under 60 seconds?
- Map-Reduce-Reduce – Can MR be made more efficient for multiple MR jobs?
- How should Pig integrate with workflow systems?
- See more: http://wiki.apache.org/pig/PigJournal

Learn More

- Visit our website: http://hadoop.apache.org/pig/
- On line tutorials
  - From Yahoo, http://developer.yahoo.com/hadoop/tutorial/
  - From Cloudera, http://www.cloudera.com/hadoop-training
- A couple of Hadoop books are available that include chapters on Pig, search at your favorite bookstore
- Join the mailing lists:
  - pig-user@hadoop.apache.org for user questions
  - pig-dev@hadoop.apache.com for developer issues
- Contribute your work, over 50 people have so far